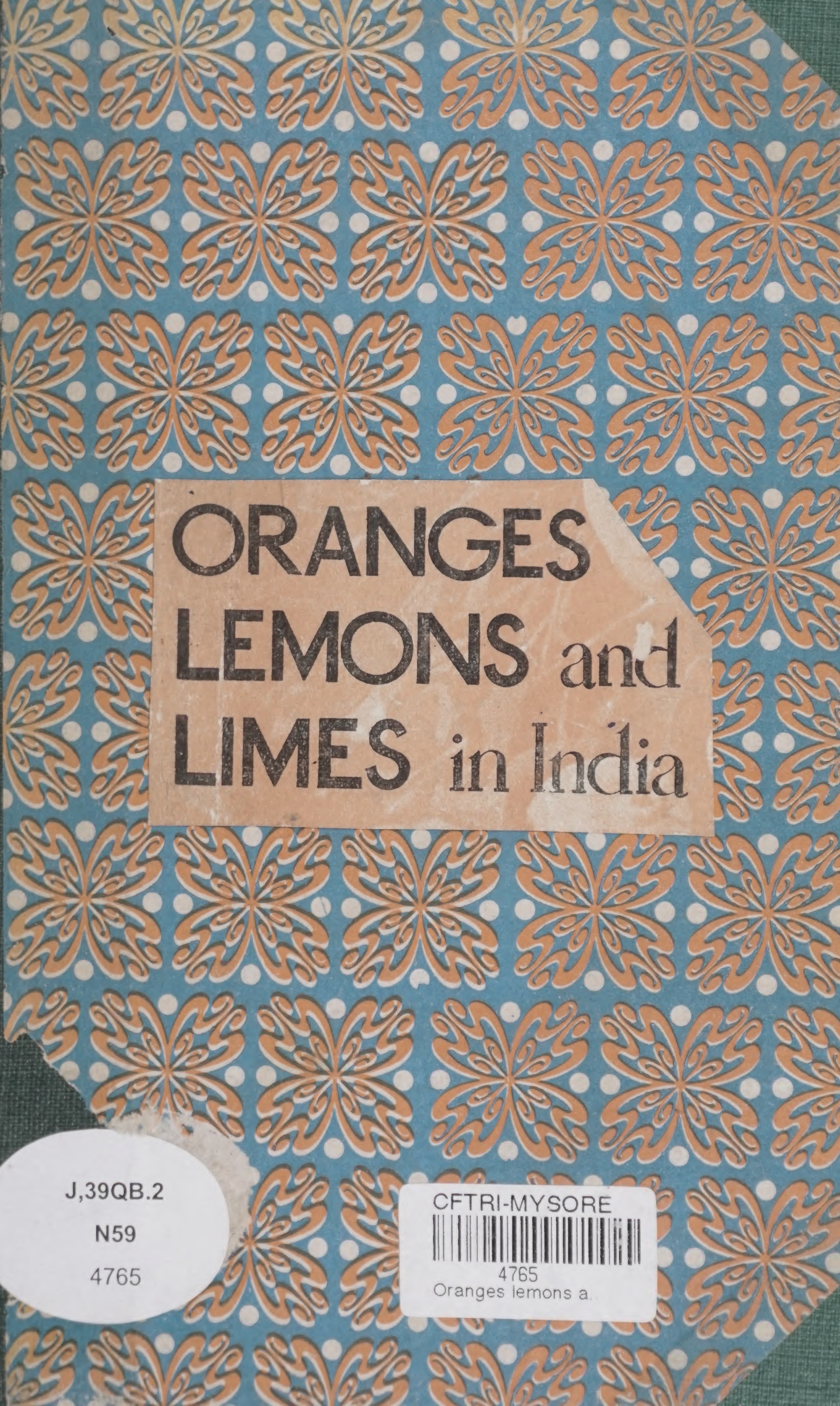

ORANGES LEMONS and LIMES in India

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Farm Bulletin No. 15

ORANGES LEMONS and LIMES in India

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By

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ORANGES, LEMONS AND LIMES IN INDIA

THE citrus fruits—oranges, lemons and limes—have been cultivated in South China, Malaya and the sub-Himalayan parts of Assam from time immemorial. From here, they spread to other tropical and subtropical parts of the world possessing a suitable climate. Next to the mango and the banana, citrus fruits represent the third largest fruit industry of India, occupying about six per cent of the total area under fruits.

Oranges, lemons and limes are all members of the same botanical family, *Rutaceae*.

Oranges are the most refreshing, delicious, wholesome and health-promoting juicy fruits, and as such deserve a prominent place in our daily dietary. Orange juice is immensely rich in vitamin C, and is a good source of vitamins A and B. Besides vitamins, the juice contains fruit sugars, fruit acids, minerals (calcium, phosphorus and iron) and alkaline salts which contribute health-promoting ingredients to the human diet.

Oranges are not only used as fresh fruit all over India, but their juice is also largely used for preparing refreshing beverages. For keeping perfect health, oranges should be consumed regularly at breakfast. An orange served as such or in juice form stimulates the appetite. The inner white peel and rag of the orange, if consumed along with the juice and pulp, provide bulk and help to relieve constipation and keep the inside of our bodies clean by their laxative effect.

Limes and lemons are as rich in vitamins, minerals and alkaline salts as the oranges, but not so in fruit sugars. They are highly acidic, and as such are not consumed as fresh fruits, but are largely used for flavouring dishes of vegetables, fish, meat and salads. The juice of limes and lemons when mixed with sugar makes the most delicious and refreshing beverage and sherbet. Limes and lemons are also largely used for making pickles all over India.

The inner white peel of the citrus fruits contains a substance known as pectin which makes these fruits very valuable for making marmalades and jellies, either when used by themselves or in combination with other kinds of fruits low in pectin.

Orange and lemon oils are obtained from the upper rind of these fruits and are used for flavouring purposes. Citric acid and citrate of lime are made commercially from lime or lemon juice. The juice of either lime or lemon is a natural cosmetic. It is excellent for external application as a hair rinse, as a skin lotion and also as a mouth wash.

SWEET AND MANDARIN ORANGES

The oranges grown in different parts of India are of two distinct species or family groups—sweet oranges (*Citrus sinensis*), and mandarin oranges (*Citrus reticulata*). Typical examples of the sweet oranges grown in India are the *Mosambi* of the Bombay Deccan, the *Malta* of the Punjab and the *Sathgudi* of south India. The mandarin group includes all types of loose jacket oranges commonly called by the Indian name of *santra,* such as the *Nagpur Santra, Coorg Santra* and *Assam Santra.*

Fruits of sweet and mandarin oranges differ greatly from one another in their physical structure. Sweet oranges are generally round to oval in shape, and heavy in weight. Their rind is leathery and adheres tightly to the pulp-ball within. The segments of the pulp-ball remain tightly attached to one another. The centre of the pulp-ball is more or less solid.

The mandarin or *santra* oranges, on the other hand, are round in shape and flattened at both ends. They are relatively light in weight. The rind is brittle and adheres very loosely to the pulp-ball and can readily be separated from it. The centre of the fruit is widely hollow, and the segments of the pulp-ball can be easily separated from one another.

LIMES AND LEMONS

In common parlance, the English name 'lemon' is applied to many different kinds of *nimboos* grown in India. This is not correct. Lime and lemon are in fact distinctly different species of citrus fruits. The *Kagzi* (or *Kagdi*) *Nimboo* which is cultivated in many parts of India is a typical lime.

The lime is a dense, bushy, thorny tree with small, winged leaves and pure white flowers. The fruit is small, round or slightly oval, about one to 1½ inches in diameter. The rind is extremely thin, and the pulp is juicy, pale greenish in colour, and highly acidic. The botanical name of the lime is *Citrus aurantifolia* Swingle.

The lemon, on the other hand, is comparatively a large, straggling tree, with large, non-winged leaves and large, purple-coloured flowers. The fruit is large, heavy, long and prominently nippled. The rind is thick and the pulp pale yellow. The pulp is slightly less acidic than that of the lime. The typical examples of lemons cultivated in India are the *Italian Lemon, Eureka, Lisbon* and *Villafranca*. The botanical name of the lemon is *Citrus limon* (Linn) Burmann.

CULTIVATION OF ORANGES

SWEET and mandarin oranges differ from one another to some extent in their climatic requirements. The sweet oranges thrive better in a subtropical, dry climate with distinct summer and winter seasons and a low rainfall, whereas the mandarins prefer more humid and tropical summers, warmer winters and a higher rainfall. The subject of climate is, therefore, separately dealt with for each of the species.

CLIMATE FOR SWEET ORANGES

In western India, *Mosambi* of excellent quality is produced under irrigation in the dry climate of the Deccan, between 1,800 and 2,000 feet above mean sea level, in the districts of Poona, Ahmednagar and the adjoining parts of the former Hyderabad State. Here the rainfall is 20 to 30 inches, restricted to the period from June to September. The mean relative humidity is 50 per cent, and the highest maximum temperature in April and May ranges from 105° to 108°F, and the lowest minimum in January is round about 40°F.

Similarly, in southern India, *Sathgudi* of good quality is produced under irrigation in the dry districts of Cuddapah, Kurnool and Chitoor in Rayalaseema and also in the Northern Circars.

In northern India, *Malta* is mainly cultivated under irrigation in the plains of the Punjab, northern Rajasthan and western Uttar Pradesh, where the summer and winter seasons are more markedly severe and much drier than in most parts of western and southern India. Here the rainfall from June to September varies from eight to 30 inches. The climate of these parts is characterised by strong, burning hot winds during the summer preceding the rainy season, and light frosts during winter. The highest maximum temperature in May may go up to 118°F and the lowest minimum temperature in January to a couple of degrees below freezing when frosty weather of short durations may sometimes occur.

Sweet oranges do not fruit successfully in regions of heavy rainfall and high atmospheric humidity like the Konkan, Malabar, Travancore-Cochin, Mysore, Tamil Nad. Bengal, Bihar and Assam. In these regions, the trees flower irregularly at different times of the year, and the fruits do not colour and ripen properly, with the result that they become almost insipid in taste.

It would, therefore, appear that the cultivation of sweet oranges can be recommended only in the drier or less humid regions of India, with a rainfall well under 30 inches, well defined winter and summer seasons, and fairly wide variations between the day and night temperatures.

The *Malta* orange is found to tolerate a considerable heat in summer and occasional freezes in winter in the Punjab, and can be safely recommended for cultivation in the arid tracts of the Punjab and Rajasthan to be commanded by the Bhakra Nangal canal system. The climate of the Punjab plains is very congenial to the cultivation of sweet oranges. In Rajasthan, sweet oranges may thrive in Jaipur, Bikaner, Jaisalmer and Kotah districts. Similarly, their cultivation can be extended to the plains of north-west Uttar Pradesh, parts of Madhya Pradesh and north and south Saurashtra wherever irrigation is available.

CLIMATE FOR MANDARINS OR *SANTRA* ORANGES

In southern India, *santras* are grown on a fairly large scale in the equable tropical climate of the warm and humid regions of Coorg, the Wynad tract of Malabar and the lower slopes of the Nilgiris and Yercaud hills without artificial irrigation, at altitudes of 2,000 to 5,000 feet with about 60 inches of well distributed rain from April to December

Similarly in Assam also, they are grown as a rain-fed crop on the steep slopes of the Khasi hills at an altitude of about 3,000 feet with over 100 inches of rain uniformly distributed from March to November. They do not seem to thrive, however, in the humid plains of south India, West Bengal and Bihar at altitudes below 1,000 feet. Except in Assam and some of the above mentioned hills of south India, *santras* are invariably cultivated under artificial irrigation.

Santras grow and fruit well along with sweet oranges all over the dry districts of the Bombay Deccan and Hyderabad at altitudes ranging from 1,500 to 2,500 feet, with a rainfall as low as 20 to 30 inches, restricted to the period from June to September and the highest maximum temperature in April-May reaching 108°F, and the lowest minimum temperature falling to about 40°F in December or January.

The largest and the most important centre of *santra* cultivation in India, with an area of about 25,000 acres, is around Nagpur and the adjacent districts of Amraoti, Akola, Wardha and Bhandara in Vidarbh, at an altitude of 1,025 feet. This is a dry hot region, with an average yearly rainfall of 45 inches restricted to the period from June to September, an average relative humidity of 53 per cent, the highest maximum temperature of 117°F in May, and the lowest minimum temperature round about 43°F in January. In contrast to the climate of the plains of the Punjab where only sweet oranges thrive and the quality of *santras* remains inferior due to high acidity, the winter season of Vidarbh, though quite distinct, is much milder. There are no frosts and no strong hot winds, and the rainfall is much higher. In this tract, the world's finest mandarin orange, called *Nagpur Santra* is grown to perfection.

Trials with many varieties of *santra* in the dry canal colonies of West Pakistan have shown that they can withstand frosty weather of short durations, but the fruit is affected by sun-scald in summer, especially on the southern side. They grow and fruit heavily in such areas under irrigation, but young fruit is liable to drop or the developed fruit gets badly sun-scorched. In the eastern districts of the Punjab, however, *santras* are reported to be growing and fruiting successfully in the cooler climate of the submontane tracts like Indpur, Indoura and Nurpur in Kangra district up to an altitude of about 2,000 feet, with 60 inches rain, restricted to the period from June to September.

It would be seen from the study of the climates of the chief *santra*-growing centres in India that santras can be cultivated with more or less success in any part of peninsular

India, as well as in the submontane districts of northern and eastern India at elevations from 2,000 to 3,500 feet and with a rainfall ranging from 30 to 100 inches.

Thus, *santras* may do well in the submontane tracts of Uttar Pradesh which have a climate similar to that of Kangra district of the Punjab. Also Orissa with its hot summer, moderately warm winter and 57 inches of rainfall from June to September, is another tract in which the cultivation of *santras* can be confidently recommended.

The introduction of *santra* oranges into the arid regions of Madhya Pradesh and Rajasthan can be recommended on a small scale, and in places where it is possible to provide strong and high windbreaks of *shisham* trees on the south-west side of the plantation as a protection against the hot winds that blow in summer.

SOILS

The deep, alluvial loams of the Indo-Gangetic plains, the coarse, friable black soils of Madhya Pradesh and similar black soils of the Deccan overlying strata of porous disintegrating rock called *murum* are considered excellent for growing the sweet as well as *santra* oranges.

In Vidarbh, most of the best orchards of *Nagpur Santra* are on the coarse, free-working, well-drained, black, loamy soils. They are about six feet deep and are overlying a bed of soft *murum* or coarse sand mixed with lime nodules.

Sandy or gravelly soils in the dry climates of northern India and the Deccan would not be suitable, as they would tend to dry out the surface roots in times of drought, but these soils are very suitable in the high rainfall areas like the Khasi hills of Assam and Darjeeling as they are useful in draining away the excess water. In Coorg, *santra* oranges flourish in deep but well-drained, red, loamy soils.

The roots of an orange tree penetrate into the soil as deep as five feet, but as most of its feeding roots are located in the first two feet of soil, any soil less than two feet in depth, will not induce a good growth. Shallow soils less than two feet in depth, such as are found in many parts of the Deccan, are not suitable, due to a limited soil space, roots cannot grow and expand naturally and, therefore, the trees in such soil conditions remain stunted and die in their prime for want of a proper nutrition.

Soils overlying impervious subsrata of sticky clay or hard rock, or soils situated at lower levels adjoining the banks of irrigation canals and having a high water-table within three feet of the roots, should never be chosen for planting oranges, as in such soils the water from the root zone is not able to drain away to the lower layers and thus the roots suffer from want of air, and commence rotting. In such conditions, the tree is unable to grow vigorously. The branches gradually get stunted, the leaves lose their normal green colour and turn yellow, and the tree ultimately dies a premature death.

The stiff, deep, black cotton soils of fine texture (found in the older alluviums of the Nurbuda and the Tapti), which crack badly during summer, are also not suitable for growing oranges, as they retain and hold excess moisture in the main root zone of the trees during the monsoon for an unusually long time, with the result that the roots suffer from want of air and the trees die out in the same manner as in the case of good soils overlying the impervious subsoils referred to above.

Though a moderate amount of lime in nodular form, such as is found in the orange-growing lands of Madhya Pradesh and the Deccan, is highly desirable for making the clay soils more friable and fertile, exceptionally large amounts of lime such as are found in the shallow soils on the slopes and uplands of the undulating plains of the Deccan, are definitely toxic and harmful to the orange trees. Such limy soils, otherwise called 'marl lands', are extremely poor in plant nutrients, and as such the orange trees soon begin to suffer from various kinds of deficiency diseases.

Orange trees are particularly sensitive to high concentrations of salt. Soils and irrigation water containing large amounts of salt should also be avoided. Such salty soils are found in many arid or semi-arid regions of northern India. These soils contain excessive amounts of sodium (black alkali soils) the chlorides and sulphates of calcium and magnesium (white alkali soils). High amounts of these salts prove toxic to the trees which begin to suffer from malnutrition and die soon after planting. Equally important is the quality of irrigation water. Wherever well irrigation is practised, it must be seen that the water is free from harmful salts. Generally, water that is brackish in taste contains large amounts of common salt and other salts of sodium.

VARIETIES

The sweet oranges. The most important of the sweet oranges cultivated on a commercial scale in India are the *Malta* (*Common*) and the *Malta* (*Blood-Red*) of the Punjab, the *Mosambi* of the Bombay Deccan and the *Sathgudi* of south India. Their distinguishing characters are described below.

Malta (*Common*): Fruit colour orange; surface smooth, finely pitted; shape ellipsoid varying to spherical; size medium to large; weight ½ pound or more; base (stalk end) and apex (stigma end) broad and rounded; stigmatic point indistinct, situated in a very small circular depression; rind medium thick, leathery, 1/8 to 1/4 inch; segments 10, well-defined, membranes thick; pulp light orange, fine grained, juice sacs long and plump; juice abundant; flavour good, sweetness and acidity well blended; axis (centre) solid; seeds 25 to 30.

The *Common Malta* is widely grown in the canal colonies of West Pakistan.

Malta (*Blood-Red*) : This variety is very similar to the *Malta* (*Common*), except that its pulp is light orange, streaked with red. The red colour is principally limited to certain juice sacs with little or none of the red pigment in the adjoining juice sacs. The density of the red colour of the pulp varies considerably among fruits from the same tree. This variety is reputed to have done very well, especially at Gujranwala in West Pakistan and the submontane districts of the Punjab, and is highly prized for its flavour and attractive juice.

There are several varieties of *Blood* oranges growing in the Punjab and the Mediterranean region of Europe. *Ruby Blood,* a variety introduced into West Pakistan, is reported to have given good performance.

Mosambi: Fruit colour light yellowish orange; surface rough, furrowed; shape oblate to spherical; size medium to large; weight ½ lb. or more; base rounded and stalk set into a slight depression; apex broad, even and flat with a conspicuous but shallow circular furrow (ring), about ½ inch in diameter, surrounding an indistinct stigmatic point; rind medium thick, 1/6 to 1/4 inch; segments 9 to 12, well defined, regular; membranes very thick, pulp straw yellow, fine grained, juice sacs long, thin and delicate; juice abundant; flavour sweet, acidity not blended well with sweetness; axis (centre) solid; seeds 20 to 25.

The *Mosambi* grows to perfection in the Bombay Deccan, where it is grown extensively on an area of about 20,000 acres. It turns almost insipid and lacks flavour, when cultivated in the more humid climate of south India.

Sathgudi : Fruit colour light orange; surface smooth, finely pitted; shape almost spherical; size medium to large; weight ½ pound or more; base (stalk end) and apex (stigma end) evenly rounded; stigmatic point indistinct; rind medium thick, leathery, 1/6 to 1/4 inch thick, segments 10 to 12, well defined; membranes thick, pulp orange coloured; juice abundant, flavour fairly good; axis semi-hollow; seeds about 20.

This variety is grown extensively on an area of over 5,000 acres in the districts of Cuddapah, Chitoor and Kurnool in Rayalaseema in south India.

Mosambi **orange**

Washington Navel is the variety *par excellence* of California. It is a large, round, seedless orange. The rind is thick. The membranes are thin, and the pulp is extremely tender and melting. The flavour is excellent and juice is abundant. This variety belongs to a group of oranges which are called navels. The term 'navel' has been assigned to these oranges as these fruits have a characteristic navel-like, nippled protuberance in the rind at the stigmatic end.

Of the many foreign varieties so far introduced into India, varieties of the *Navel* group seem to be the least adaptable to Indian conditions. It was seen that the *Navel* orange varieties that were imported under different varietal names in the early twenties from Australia usually deteriorated into erratic strains, giving fruits of different shapes and quality even on one and the same tree, and the pulp of the fruit had the tendency to granulate and dry up in the final stages of maturity.

Plants of true *Washington Navel* imported from Australia from time to time and planted at Bangalore are, however, reported to have given fairly satisfactory performance in favourable climatic conditions. Recently, a variety called *Bukeye Navel* is also said to be fruiting satisfactorily at Kodur in south India.

Side by side with *Washington Navel, Valencia* orange occupies a place of pride in the orange-growing regions of California. Its pulp is delicate and fine-textured, and its flavour excellent. For all practical purposes, *Valencia* is also a seedless orange, as it has only five to six seeds. The intrinsic value of *Valencia* is, however, its late ripening character. Fruits ripen very late when fruits of all other varieties are out of the market. In fact, *Valencia* is commercially more important than *Washington Navel,* as it is adaptable to a much wider range of climatic conditions than the latter.

Washington Navel thrives only in a few districts in the south of California where the climate is mild, whereas *Valencia* is much more extensively cultivated than any other orange, not only in California, but also in other orange-growing regions of the world such as Florida and Texas in the U.S.A., and South Africa.

Trials of *Valencia Late* in the Punjab have shown that this variety can be successfully grown in the plains in almost all the districts. The fruit ripens about the end of March. On the other hand, in the more even and milder climate of south India, *Valencia Late* does not maintain its late maturing character, but matures normally at the same time as *Sathgudi,* and if the fruits are retained on the tree beyond the normal harvesting season, they become less juicy and insipid in taste.

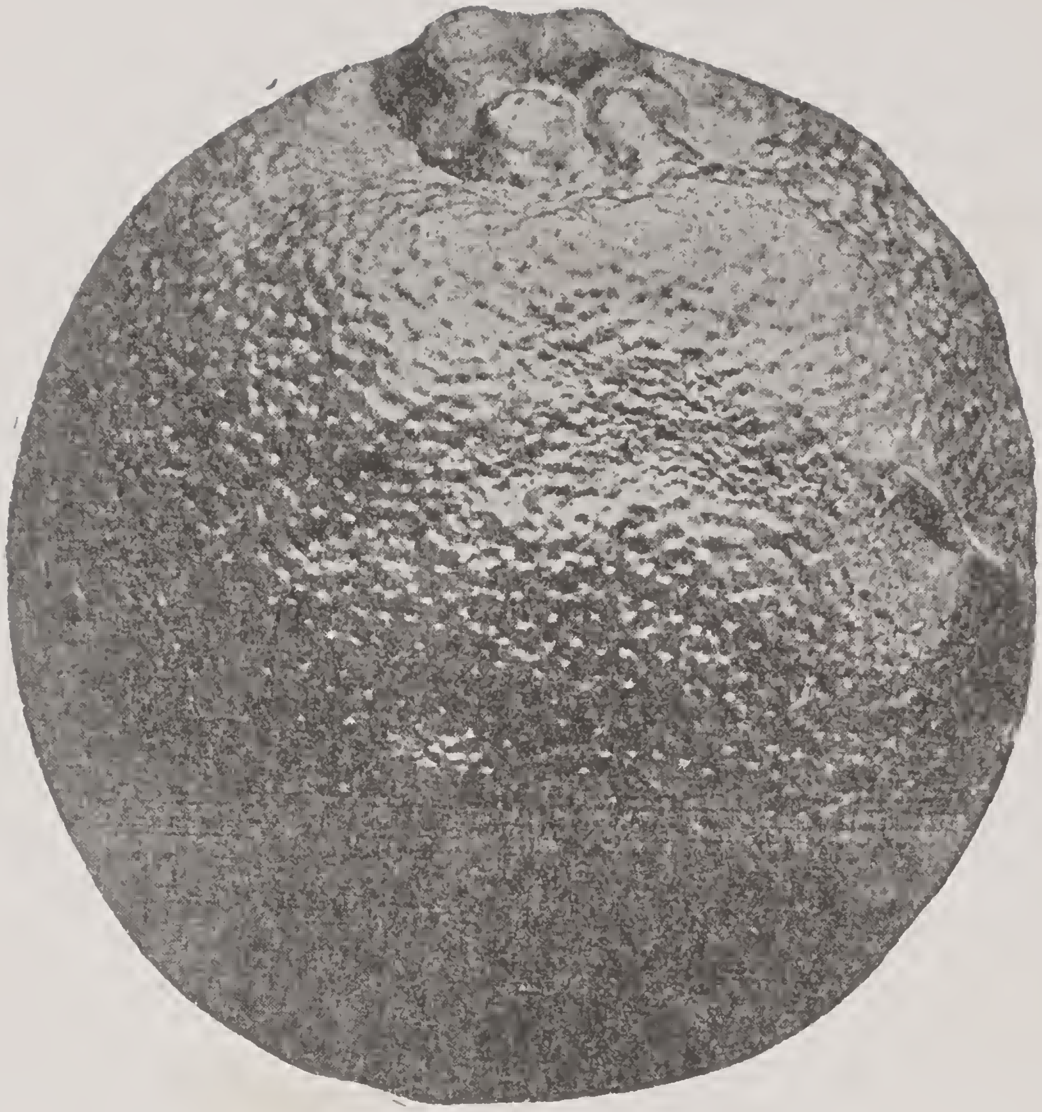
Among the other important but recently introduced sweet orange varieties tried out in the Punjab are *Pineapple, Hamlin* and *Jaffa*. *Pineapple* is famous in Florida and is produced there in a greater quantity than any other variety. It has a tender pulp, with good flavour and few seeds. In the Punjab, it has given a good performance. It is found to maintain its juicy character and its characteristic flavour and sweetness though it is found to be seedy.

Jaffa is one of the famous sweet orange varieties from Palestine. Once it was grown on a very large scale in Florida, but now it has been largely replaced by *Pineapple*. It is a fairly large, thick-skinned fruit with tender flesh, rich flavour and very few seeds. It is seedless for all practical purposes. It has also shown good performance in the Punjab, but the quality of its fruit has somewhat deteriorated.

Besides *Washington Navel* and *Valencia Late, Shamuti* is another world famous seedless orange, which is extensively cultivated in Palestine, and exported to England and other European countries during winter. The fruit is entirely seedless with an extremely tender pulp, and a sweet, rich flavour. This variety deserves a trial in the various dry regions of India as it seems it has not been introduced into any part of India as yet.

The mandarin oranges. The most important of the mandarin oranges cultivated on a commercial scale is the *Nagpur Santra* which is considered as the world's best mandarin. Its main distinguishing characters are described below.

Fruit colour deep orange; surface smooth, but slightly undulating; shape oblate; size large, 3½ x 4 inches; weight four to six ounces; base (stalk-end) slightly drawn out and warty, with glandular irregular furrows; apex (stigma end) deeply depressed with typical star-like radiating furrows from the stigmatic point; rind thin, glandular, loosely attached to the pulp-ball below by means of many fluffy strings; oil-glands prominent, not uniform; axis (centre) hollow, very large, 1 to 1¼ inch across, with a few white strings filling the



Nagpur Santra **orange**

hollow; segments 10, well-defined, easily separating; membranes thin, tender; pulp bright orange coloured, tender; juice sacs large, plump, coarsely interwoven; juice abundant, sweet, sweetness and acidity well-blended, aromatic, quality excellent; seeds few, about 7, small and green when cut.

Other varieties of *santra,* viz., *Assam Santra, Sikkim Santra* and *Coorg Santra* seem to be the ecological types of the *Nagpur Santra,* and they differ somewhat in the eating qualities of the fruit from the last-named, as influenced by the different climates in which they are grown. A variety called *Ladu,* grown on a small scale in Uttar Pradesh and the Deccan, deserves special mention. The fruit of *Ladu* is slightly smaller in size than the *Nagpur Santra,* and is shaped like a semi-flattened baloon. It is a fairly vigorous and thickly-growing, round, dome-shaped tree, bearing a profuse crop under the Deccan conditions. The pulp is almost seedless, and is fairly sweet.

Important mandarin varieties tried: Among the foreign mandarins which have been successfully introduced into India, *Dancy* is the most important. It is the most highly prized of all the mandarins in the United States of America. The largest plantings are in Florida, but there is a considerable acreage in California too.

As cultivated in the U.S.A., it is an orange-red coloured fruit of small size, 2¼ x 2 inches, thin skin, 10 to 14 segments, dark orange, tender, melting pulp, rich, sprightly flavour, and seeds six to 20. In proportion to the size of the fruit, the seeds are rather too numerous.

Dancy was tried at the Government Fruit Farm, Mirpurkhas, West Pakistan, in 1919. Here in the arid desert climate, the variety was found to grow vigorously and bear a heavy crop, eight-year-old trees yielding as many as 500 fruits each. Under Mirpurkhas conditions, the fruit showed only nine to ten segments, and became almost seedless, sometimes showing not more than three undeveloped seeds. The pulp was rather coarse-grained, and with a tendency to granulate on full maturity of the fruit. The juice was abundant in half-ripe fruits, but the fully mature fruits had almost dried-up juice sacs. The only method of avoiding the drying up of juice sacs was to pick the fruit in semi-ripe condition and not to allow it to remain on the tree till fully coloured.

Another foreign mandarin which deserves a fair trial in many parts of India is *Emperor*. It is a large-fruited mandarin extensively grown in Victoria and New South Wales in Australia. It is at present being cultivated on a small scale at Saharanpur in Uttar Pradesh.

Of the recent introductions at Lyallpur (Pakistan), a mandarin called *Kinnow*, introduced from California (U.S.A.), has been found to be more promising than the local mandarins which suffer from sunburn. *Kinnow* is a new hybrid mandarin evolved at the California Citrus Experiment Station, Riverside. In view of its good performance in West

Pakistan, *Kinnow* deserves a trial in the Punjab and other regions of northern India.

PROPAGATION

Since the commercial varieties of oranges do not reproduce true by seed, they must be propagated by a vegetative method known as 'budding'. This consists in inserting a bud of the choice variety to be propagated into the stem of a seedling of another species of citrus. The bud of the choice variety so inserted is called the 'scion' and the seedling plant on which it is budded is called the 'stock'. The new plant thus prepared by combining the stock and scion is called a 'bud-graft' or a 'budling'. Stocks generally termed as 'root-stocks' in this Bulletin are stocks grown from seeds of a wild species of lemon on a field scale in a nursery for about a year and when about 1½ feet in height, budded with the scion variety.

Not all types or species of citrus are good as root-stocks. Though it may be possible to unite one kind or species with another, the tree resulting from the union may not be commercially satisfactory. The stock and scion must not only be capable of uniting, but also be capable of producing long-lived, productive trees.

By experience and by experiments it has been found in all the important orange-growing countries of the world that different species of citrus stocks vary in their adaptability to growth on different soils and under different climatic conditions as well as with different scion varieties, and that a certain natural affinity must exist between the stock and the scion to enable them to unite and make a successful bud-graft.

Not only do the different species and varieties of oranges require different stocks, but a combination of stock and scion which is satisfactory under one set of climate or soil conditions may fail entirely in other conditions. This means that we have to discover by experimentation the best stock for each species of variety of orange in each region where oranges are grown.

The most commonly used stocks for propagating the sweet as well as the mandarin oranges in India are *Jamburi* and *Kharna* or *Kharna Khatta*. *Jamburi* is universally used for propagating *Mosambi* and *Nagpur Santra* in the Bombay Deccan, erstwhile Hyderabad State and Vidarbh. Similarly, *Kharna Khatta* is the stock used for propagating *Common Malta* and the mandarins in the Punjab and Uttar Pradesh.

In an experiment conducted at Montgomery in West Pakistan, in which several species of lime, lemons and citron were used as root-stocks, it was found that while *Kharna* was a good stock for grapefruit and *Common Malta*, it was not a very suitable stock for *Malta Blood Red* for which *Jatti Khatti* proved to be the best stock. *Mokari* (citron) and *Mitha* (sweet lime) proved unsuitable stocks for sweet orange and grapefruit. It is also reported that *Jatti Khatti* has been found to be the best for the *Valencia Late* orange.

In wide contrast to the cultural practice followed in the western, northern and central India, the oranges in southern and eastern India have always been grown from seed, with the result that in orchards of the same variety, large variations between orchard trees have been observed in respect of fruit quality, and such fruit characters as shape and size of fruits.

It is only since 1935 that 'budding' has been introduced as an improved method of propagation in south India, and experiments conducted at Kodur to find out the best stock for the *Sathgudi* orange. In these experiments, *Jamburi* has been found to be the best root-stock for *Sathgudi*, especially in light soils.

In Assam also, as in south India, the *Khasi Santra* is grown from seed, and no vegetative method of propagation was practised until 1942, when a root-stock experiment was started at Burnihat. In this experiment, *Soh myndong* (*Citrus limon*) was found to be the best stock for the *Khasi Santra*.

In root-stock experiments conducted at Poona since 1943 in which seven different root-stocks were tried out for propagating the *Mosambi* orange, it was found that *Mosambi* made poor growth on sweet *Chikna, Galgal* and *Kharna* (all these three varieties are native to Saharanpur in Uttar Pradesh) and the *Mosambi* tops died out within three years of budding on *Kagzi Nimbu* (acid lime) and *Sadafal* root-stocks. *Sadafal* is also a type of lime native to Saharanpur.

In this experiment, ony two stocks, namely, *Jamburi* and the *Rangpur* lime, were found to be satisfactory from the point of view of the vegetative vigour of the scion and production of fruits; but comparing these two between themselves, it was noticed that *Mosambi* on *Rangpur* lime, though slightly less vigorous in vegetative growth, gave a slightly higher yield of fruits, of much better quality and size, and was comparatively less susceptible to a deficiency disease called Mottle Leaf.

The sweet lime (*Mitha nimbu* of Nagpur) is popularly believed by some growers to be a satisfactory stock for budding *Nagpur Santra* at Nagpur. It is the general belief among growers in Nagpur that the *Nagpur Santra* on sweet lime produces much better quality of fruit with tighter skin than on *Jamburi,* which is commonly used as a stock in Vidarbh; but *Jamburi* is generally preferred as a root-stock, as it grows faster in the nursery and the *Santra* grows more vigorously on it than on the sweet lime. This belief has not, however, been experimentally confirmed.

The sweet *Chikna* of Saharanpur when employed as a root-stock for *Mosambi* at Poona was found to be very disappointing. The *Mosambi* on sweet *Chikna* suffered heavily from the deficiency disease Mottle Leaf.

The influence of the most important and widely used root-stocks in various parts of India on the characters of the various orange varieties should be known to the grower so that he may choose the right kind of stock for his own locality.

Finding the best root-stock for each orange variety for the different parts of India is, however, so difficult as to almost defy accomplishment. The few root-stock experiments which are at present being conducted on Government farms in different parts of the country when concluded may throw some light on the many difficult cultural problems that confront growers in making orange-growing a successful venture.

In the meantime, the experience of the growers themselves in each citrus-growing area should serve as a basis for selecting the right kind of root-stock for their own tracts.

Raising of root-stocks in a nursery. Tree-ripe fruits of the root-stock variety are obtained and their seeds extracted and preserved in wood ash till they are sown. The seeds must be sown as soon as possible, as, otherwise, they dry up and lose their germinating power within about a fortnight after extraction. The time of sowing will depend upon the ready availability of mature fruits. In the Punjab and Uttar Pradesh, *Kharna* seeds are sown either in September or in the beginning of February. In Vidarbh, the Deccan and south India, *Jamburi* seeds are sown in May-June or in September-October, when fruits are generally available.

Seeds are closely sown with a spacing of one inch, in rows which are three inches apart, in a small, well-drained bed. The soil of the bed is well-pulverised and heavily manured with leaf-mould or well-rotted cow-dung. The seeds germinate within three weeks of sowing. The bed is given overhead watering till the seedlings attain a height of three inches, and later flow irrigation is applied during the dry weather. After one year, the seedlings which would have grown about a foot high are lifted and transplanted in the nursery in regular rows.

Transplanting of root-stocks. Long beds, about ten feet in length and three feet in width, are prepared. These are then levelled and heavily manured. The root-stock seedlings are now dug out with bare roots when the weather is cloudy and moist, and transplanted in rows in the nursery-beds with a spacing of one foot in the row and two to three feet between two consecutive rows. Thus, each bed would accommodate three rows of seedlings. Necessary intercultivation is given to keep off weeds and the beds are regularly watered at short intervals during the dry weather.

Removal of side shoots. As the seedlings grow tall, they may be allowed to grow bushy near their heads, but their side growths near the base of the trunks should be removed from time to time so as to maintain a perfect smoothness of the bark up to a height of six to nine inches from the ground. These growths should be carefully removed by means of a pruning shear and very close to the stem so as to leave no stubs. It is on this smooth part of the stem that the budding operation is to be done.

When to bud. The root-stocks when about a year old and $\frac{1}{4}$ to $\frac{1}{2}$ inch thick are budded with the scion variety. The budding operation is most successful when the root-stock seedlings are putting forth new growths and the weather is fairly cool and dry. In Gujarat, the Deccan and Vidarbh, budding is best done in the months of October, November and December. In Uttar Pradesh and the Punjab, February-March and August-September are considered the best months for budding.

Heavy rains at the time of budding are not desirable, as the rain water will enter the operated parts and may cause the rotting of the bud. In parts of south India which get rains from the South-west as well as the North-east monsoons, the clear weather prevailing from July to September is considered the best for budding.

During the above-mentioned seasons in the different parts of India, the root-stocks are in great vigour and put forth new shoots and leaves, and in this condition their bark slips easily when operated for budding. A skilful gardener, however, invariably examines the state of the bark of each plant by tearing it slightly with his nails, and if it slips or comes off without sticking to the wood below, the root-stock is considered fit for budding. If the bark fails to slip on a number of seedlings in the nursery, the budding operation is postponed and the seedlings are given proper cultivation, manure and irrigation to activate the flow of sap.

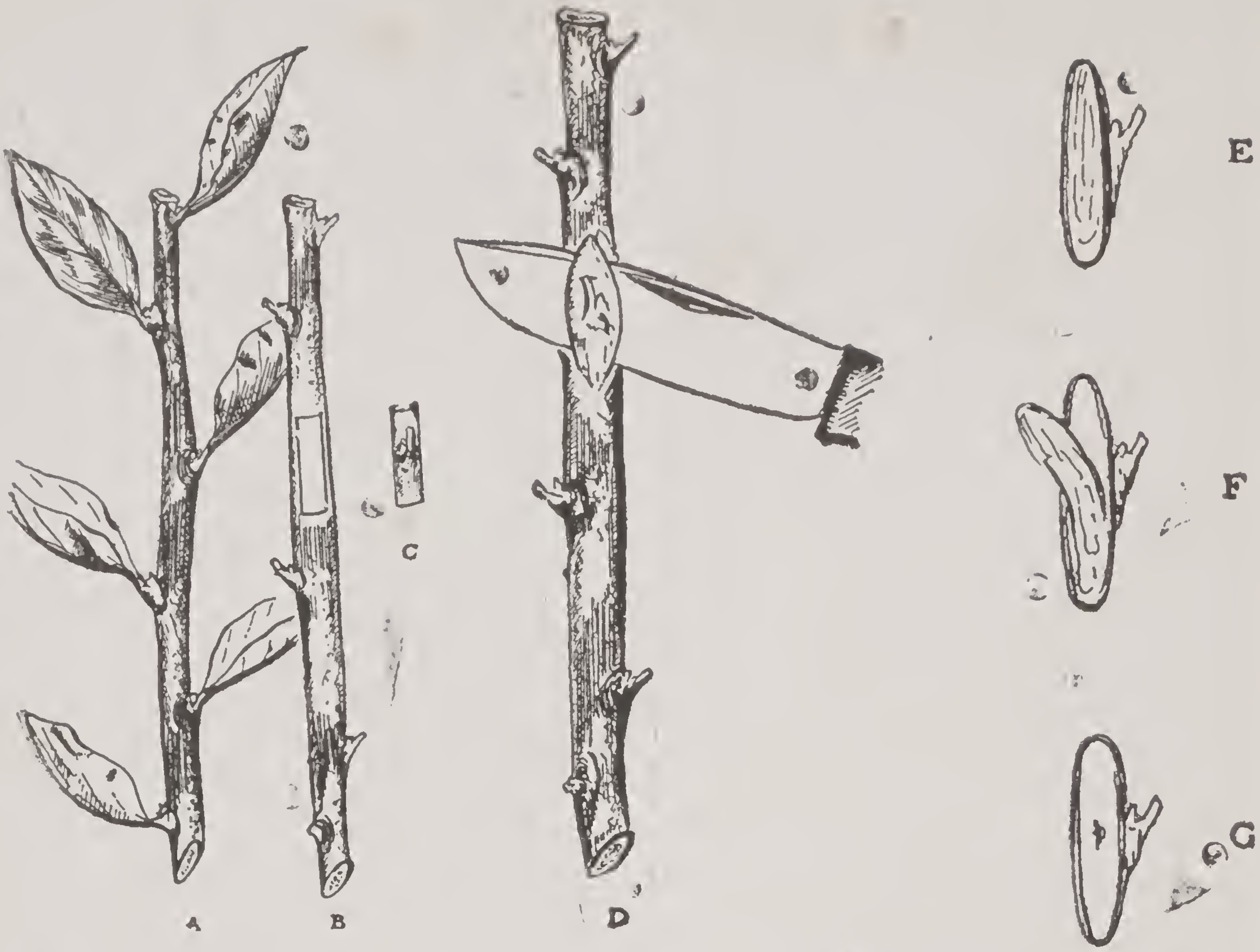
Scion (*Bud-wood*). If the root-stocks are in proper condition, budding is commenced. For budding, bud-sticks of the scion tree are obtained. A small twig of the scion tree which is intended to be propagated, is cut. This twig is called 'bud-wood' as it supplies buds for budding the root-stocks.

Bud-wood is chosen from semi-mature wood of the basal portion of the current season's growth. Round, green twigs with white streaks, swollen buds and mature leaves are selected. For budding on a large scale, several bud-sticks, about six to nine inches in length, are cut, and their leaves removed, but keeping the leaf-stalks attached to the stem. The bud-sticks are then tied in small bundles and carefully wrapped in moist sawdust or moist sphagnum moss. The bud-wood thus wrapped in moist moss or sawdust can be kept in fresh condition for about two weeks, and can be sent by post to any part of India.

Budding operation. The root-stock seedling is operated on its stem at a height of about six to nine inches above the ground. Two ways of operating the stock and inserting the bud are in common use: (1) a single vertical incision is made in the bark of the stem which is then bent by the operator towards himself and the bud is inserted into the gaping cut, and (2) the incision is made in the shape of the letter T and the bud is pushed downwards into the cut. The operator may use whichever method seems quicker and easier to him.

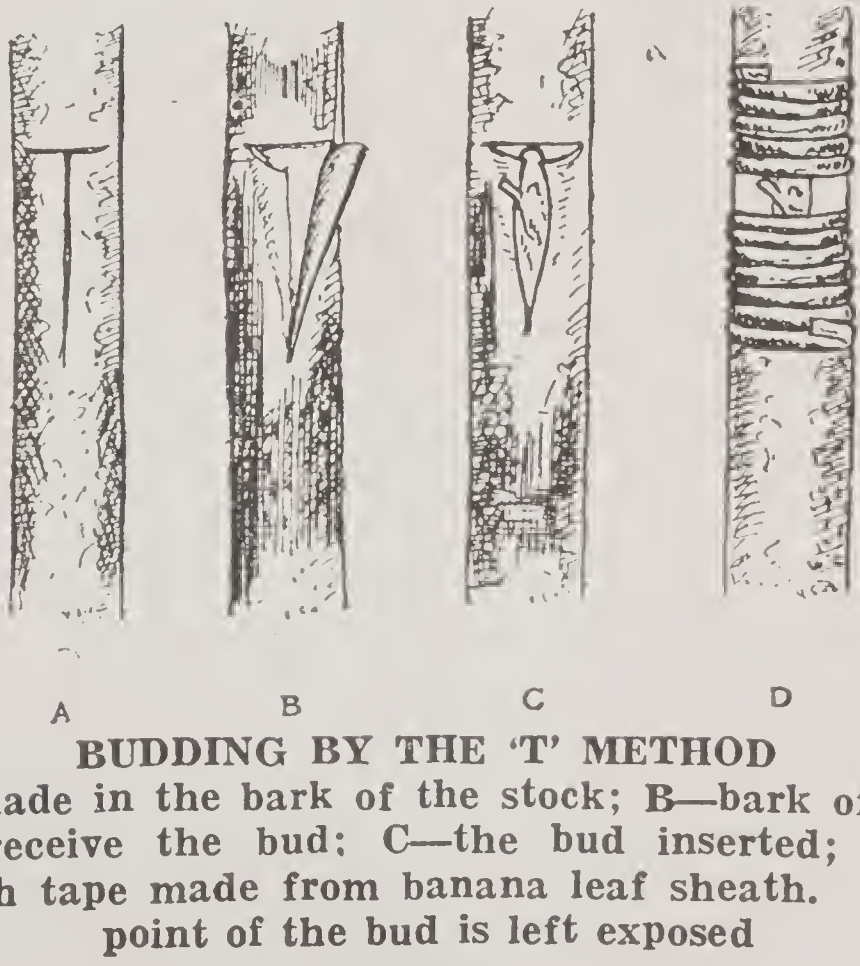
The stock is first operated before the bud is cut out of the bud-wood. The vertical cut should not be deep. The aim should be merely to cut through the bark only. The surface of the wood should not get scratched by the knife.

Next, the bud-stick is taken in the hand. To remove a bud from it, two transverse cuts are made, one about half an inch



BUD-WOOD AND REMOVAL OF BUDS

A—round, mature, leafy twig with swollen buds; B—leaves are cut away from the bud-stick keeping the leaf-stalks (petioles) attached to the buds and a rectangular bud slipped off the wood of the bud-stick; C—the bud shield ready for insertion in the stock; D—removal of bud with wood chip; E—cut surface of bud showing the layers of bark and wood chip; F—the wood chip being removed from the bud; G—the bud shield showing the inner surface of the bark after removal of the wood chip



BUDDING BY THE 'T' METHOD

A—'T' cut made in the bark of the stock; B—bark of the 'T' cut opened to receive the bud; C—the bud inserted; D—the bud wrapped with tape made from banana leaf sheath. The growing point of the bud is left exposed above and the other below the selected bud, and the ends of these cuts are joined with two longitudinal cuts. Then with the point of the budding knife, the upper right hand corner of the bud patch is slightly loosened and a slight jerk given by means of the ivory end of the budding knife so that the entire bud slips off the bud-stick. The rectangular piece of bark with the bud in the centre and the leaf-stalk attached to it is called the 'bud-shield'.

There is another method of removing the bud-shield from the bud-wood which is also widely practised by nurserymen in some parts of India. The bud is cut longitudinally, about an inch long, with ample wood-chip which is then carefully removed by the finger nails without scratching the inner side of the bud-shield.

The bud-shield should not be allowed to remain exposed to the air as, otherwise, its underlying healing tissue will dry up and be destroyed. The professional budder in India always keeps the bud-shield on the tip of his tongue to keep it moist while he is loosening the bark of the root-stock. The bud-shield then is dexterously pushed snugly into the cut made on the stock without any loss of time. The bud after insertion is ready to be wrapped up.

For wrapping the bud, the operator uses a strip or a tape of banana leaf-sheath, torn to a length of about two feet. For making this tape, a piece of dry banana leaf-sheath is dipped in water for some time, and tape-like strips are torn out of it when it becomes pliable. In wrapping, the tape must be spirally and tightly drawn from below upwards around the operated stem so as to leave the bud exposed. The tape is then spiralled round the stem about an inch above the bud and given a finishing twist.

Forcing the bud and topping the stock. The first indication of the bud having taken will be the falling off of the little bit of leaf-stalk that was left adhering to it. If the bud remains green for three weeks and the leaf-stalk has fallen, it may be concluded that it is living, and has united with the stock.

In the fourth week after budding, the bud begins to develop and begins showing signs of growth. At this stage, it is necessary to check the growth of the stock so that only the bud can grow on it. This is done by cutting off the entire top of the stock with a pruning shear from six to eight inches above the bud. When the young bud-shoot is about three inches in length, the stem of the stock to within two inches of the bud-shoot may be cut off.

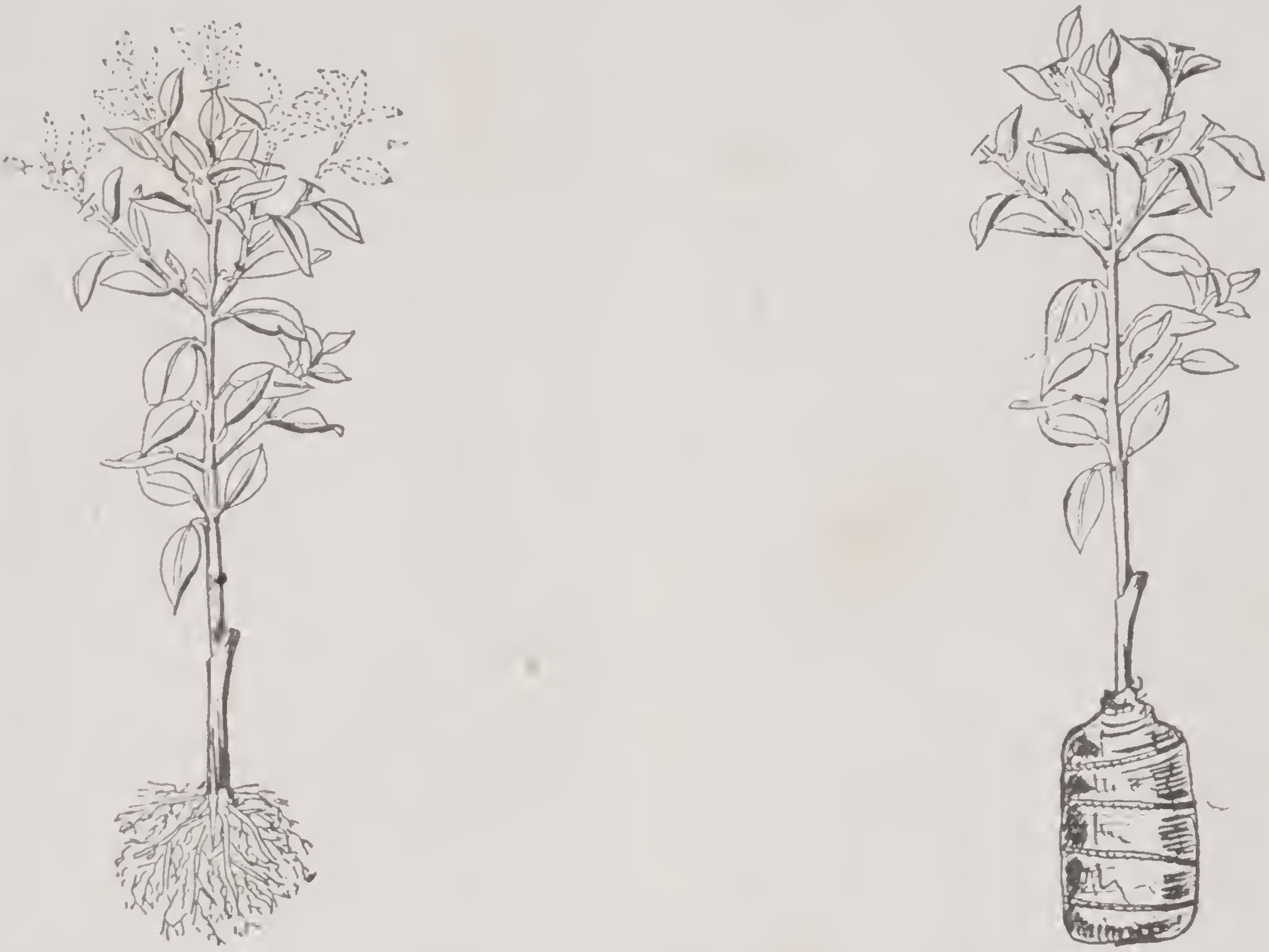
In the meantime, the part of the stem below the bud-shoot will throw out many side growths. These growths should be rubbed off with the hand as soon as they emerge as, otherwise, they would outgrow the bud-shoot and eventually kill it.

After-care of budlings. The budded plants, called 'budlings', grow vigorously and put forth several flushes of young growths during the period following the operation of budding. The budlings should be given timely watering and necessary intercultivation from time to time. In about a year after budding, they develop a luxuriant head of broad, dark green leaves and correspondingly a large mass of thickly-set fibrous roots near the surface of the soil. Budlings which are now about two to 2½ feet tall and half an inch thick at the bud-joint are ready for transplanting in their permanent places in the orchard.

Removal of budlings and their transport When a budling is dug out from the ground with its roots, a part of the root-system naturally is destroyed, and the remaining roots are unable to sustain the original head of the plant. The leaves of plants, especially if they are young and tender, loose water and droop immediately if roots are damaged in the process of digging out the plant.

To preserve freshness in the plants, it is better, therefore, if the young immature top of each budling is slightly pruned before the plant is dug out.

Budlings to be planted in the rainy season should preferably be dug out from the nursery when the monsoon has properly set in and the weather is moist. In the dry climate of



A bare-root budling *(left)* showing thickly growing fibrous roots close to the trunk and the ends of the younger growths of the top removed for reducing transpiration. The initial success in establishing bare-root budlings largely depends upon the presence of these fibrous roots. Such budlings are specially prepared by reputed nurserymen in the Bombay Deccan, by pruning the tap-root and transplanting plants in the nursery, once or twice before selling out, and *(right)* a balled citrus budling wrapped and ready for transport. Tips of the young top shoots are pruned to reduce transpiration

northern India, planting immediately before spring is preferred to planting in the rainy season. The plants are dug out with sufficient moist soil sticking to their roots. Every budling is individually dug out with a ball of soil (*gachi* or *chakki*) in which most of the surface roots will be preserved. The *chakki* or *gachi* is then tied in gunny cloth. If such balled plants are to be despatched to growers by rail, the tied root balls are first immersed in water and then the plants packed four to six in a bamboo basket or a dealwood box.

In the milder climate of the Bombay Deccan, it is not necessary to dig out budlings with large soil balls. They can safely be dug out with their bare roots with a little moist soil attached to them. About 50 to 100 of such bare-root plants can be put together in one bundle and their root-ends tied in a gunny cloth for despatch by rail. While tying them together, a light sprinkling of moist soil is done on the roots so as to cover them fully. The tied root-end of the package is then immersed in water for a short while before it is despatched.

On arrival at the destination, the plant package should be copiously watered and stocked in a shady and moist place till the budlings are planted in the orchard.

PLANTING

The site of the orchard should be well-protected from high winds. If there is no natural protection like a distant hill or a forest, a windbreak of quick-growing trees should be planted in the south-west (for details of planting a windbreak see page 40).

The land should first be cleared of any bush or jungle. Deep-rooted shrubs and weeds must be entirely dug out with all their roots and removed from the land. Care must be taken to select land which is at least four feet deep with a previous substrata. The land must be levelled, and slopes, if any, should be regulated so that every tree of the orchard can easily get the irrigation water from a common source.

In the hilly and moist regions, where plantings are done on steep slopes, it is better to prepare bench terraces which should be at least ten to 15 feet wide. These terraces should run parallel to one another, and one above the other, across the slope of the hill.

In favourable soil and climatic conditions, both sweet as well as *santra* oranges may be spaced 20 to 25 feet apart on the Square System. Seedling *Sathgudi* oranges which are more spreading than budded plants are planted 27 to 30 feet apart in south India. On poorer soils or in difficult climates where the trees are unable to make rapid growth, oranges may be planted 15 to 18 feet apart. Holes, 2½ feet x 2½ feet x 2½ feet, may be dug and filled with the topsoil mixed with about 50 pounds of farmyard manure, two pounds of bonemeal and five pounds of wood ash. Water should be applied to the holes seven days before the trees are planted, so that the soil settles down properly. The planting of the trees should be done when the soil in the holes comes into a workable condition.

The commencement or the middle of the South-west monsoon (July-August) is the best time for planting in most parts of southern India. In the heavy monsoon areas, however, the *santra* oranges may be planted at the end of the heavy rains in September. It is essential to see that the trees are planted in the orchard at the same level as the ground surface at which they stood in the nursery. Under no circumstances should the bud-joint be buried underground. In fact, it should remain at least four to six inches above ground level.

If the budling happens to be a bare-root plant and not 'balled', it is very essential to see at the time of planting that the moist soil is firmly pressed around the roots, and that under no circumstances the plant is loosely planted. Next, an irrigation basin of two feet radius around the trunk is made and the plant copiously watered.

CARE OF THE YOUNG ORCHARD

The irrigation basins may be enlarged from time to time so as to suit the ever-increasing size of the plants. Young trees have to be regularly watered throughout the year during the dry seasons, and the area around the trees should be kept absolutely clean of weeds, particularly during the monsoon.

Trees generally take seven to eight years to cover most of the ground of the orchard. Till then, every year, the unoccupied soil between the young trees should be cultivated and green manured during the monsoon. During the winter,

***Santra* orange trees are irrigated in round flat basins at Nagpur. Each basin is connected with a water channel running between the tree rows**

inter-crops of vegetables and leguminous crops like gram and berseem may be taken on it, if additional water facilities are available.

The growths put out by the stock part of the stem below the bud-joint should be smothered or rubbed out with the hand as soon as they show signs of sprouting.

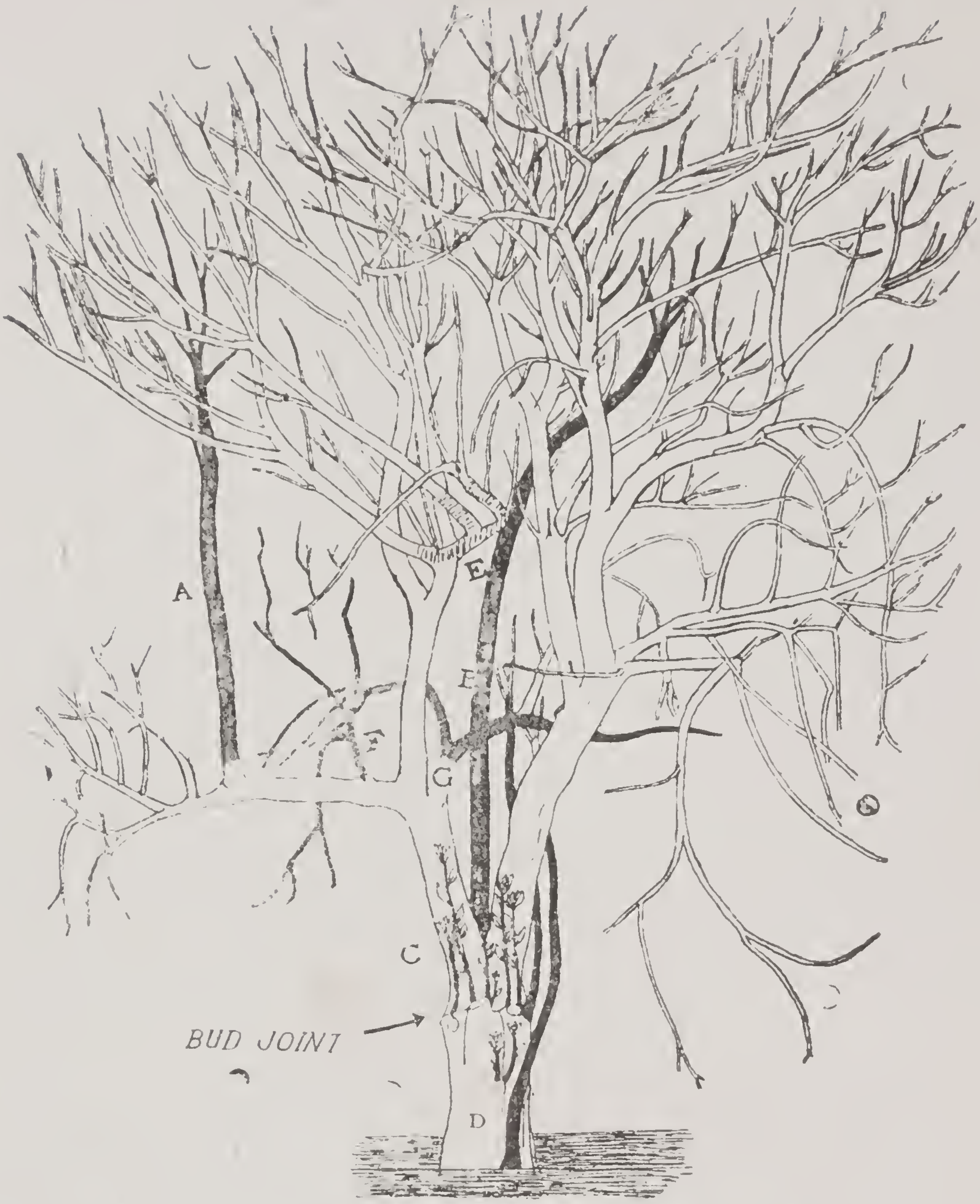
Oranges are relatively shallow-rooted trees. Most of their roots are surface-feeding, the top ones being very near the surface of the soil. The hand-digging of the soil in the basins should be necessarily shallow so as not to injure the thick roots.

Young trees should be manured at least once a year. In northern India, manuring is done in winter (December-January) followed by the application of a dose of ammonium sulphate in April-May after fruit-set. In other parts of the country, manuring is done in the beginning of the monsoon. A one-year-old tree may be given a mixture of 20 pounds of farmyard manure and ½ pound of castor cake. From the second year onwards, the above quantities should be increased by ten pounds and ½ pound, respectively, every year, up to the end of the sixth year. The manures should be spread evenly on the entire surface of the water basin, and dug into the soil by means of a hand spade.

The *Loranthus* parasite, if growing anywhere on the branches of trees, shoud be removed at once. The trees should be sprayed or dusted for pests and diseases at the proper time as detailed elsewhere in this Bulletin.

Pruning and training of young trees. The main branches of the tree should be encouraged to arise on the trunk not less than a foot, and not more than 2½ feet above the bud-joint. If the crown of the tree is taken still higher on the trunk, the tree is in constant danger of being blown down in a windy situation, and its trunk getting severely sunburnt.

A young orchard of *Nagpur Santra* at the Nagpur Agricultural College garden intercropped with brinjal in-between the tree rows



A *Mosambi* orange tree dangerously neglected for a period of four years after planting. During the period, it is overgrown with water-shoots and crossing branches which have formed bad crotches. Also mark that the foundation leading branches have been erroneously allowed to start very near the bud-joint

A—a typical water-shoot which has arisen from a high point on one of the main branches and has definitely impoverished the extreme part of the branch

B—water-shoot which has arisen right from the central fork and is fattening itself as if it were one of the original foundation leaders

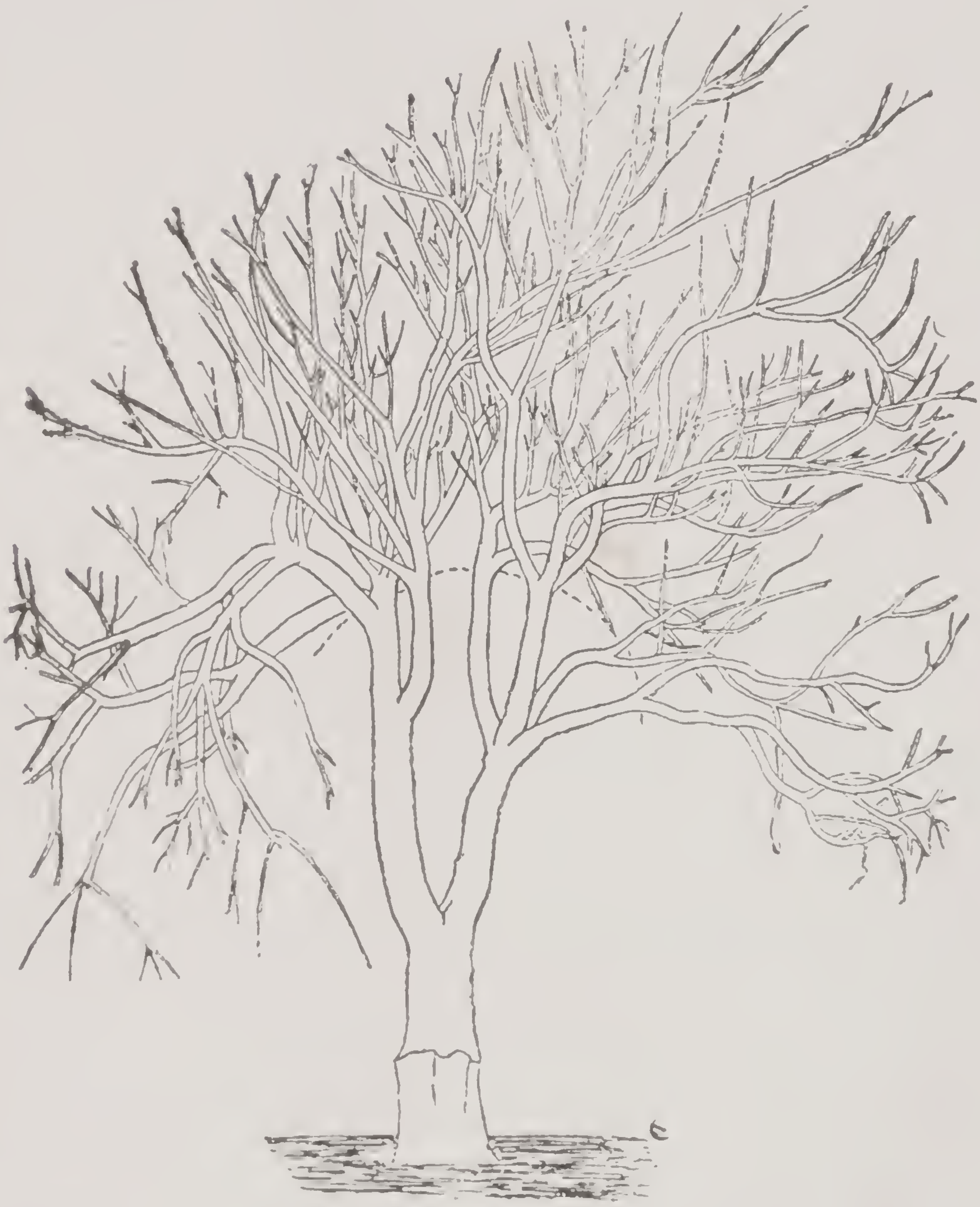
C and D—numerous water-shoots rising below and above the bud joint. Water-shoots from below the bud joint (from the stock) are usually stronger and would in the long run overpower all growths of the scion top if allowed to grow unhampered

E (striped)—an awkwed crotch due to close spacing of branches

F—a weak branch which had fallen behind in competition with its neighbours

G—an undesirable crossing branch

After allowing the tree to grow unhampered for about six months or a year, it should be pruned for the first time to form its foundation framework of main branches. At this stage, it will be seen that the tree is thickly overgreen with numerous branches. Out of these, select and keep two or three leading branches which are will-spaced and balanced on the trunk, and remove the rest clean with a pruning shear, without leaving any stubs.



The framework of a well-trained *Mosambi* orange tree (4 years old). Mark the stout upright main limbs raised high above the bud joint and giving the tree the shape of a beautiful vase. Scrupulous care has to be taken to remove the water-shoots. No awkward crotches have occurred due to the judicious spacing of branches which are gracefully drooping to shade the trunk and main limbs

For the first five years, the trees grow almost wild and throw out considerable quantities of leafy growths. Among these growths, the branches that are more or less obliquely inclined and are fully exposed to the sun are the useful, normal, productive branches which should be retained and encouraged to grow, but along with these there are many undesirable growths too, which should be promptly removed.

Among these undesirable growths, the most important are the water-shoots, which are easily distinguishable from the other branches. The water-shoots grow in an upright direction at the expense of other branches. They are erect, angular, sharp-edged when young, often spiny, thick growing, and bear much larger and coarser leaves. They grow with such rapidity that almost in one season they outgrow and impoverish the rest of the normal, obliquely-inclined fruit-bearing branches.

The water-shoots grow branches almost throughout their length except when they reach the top of the tree crown, where, due to full exposure to sunshine, they put out a few fruit-bearing sideshoots. These shoots grow from any high point on any part of the tree, whether it is the trunk or the side branches. They must be smothered as soon as they are seen. Growths other than water-shoots which need to be removed are the interfering and crossing branches in the centre of the tree which often fall behind other branches in competition. These interfering growths are always found in the central part of the tree within the limit of the second forking of the main limbs.

The cuts made while removing the water-shoots and other undesirable growths should be clean and close to the stem. Stubs should never be left. It is always best to maintain orange trees in good shape by doing a little pruning once or twice in a year, as a heavy pruning of thick wood after a lapse of years is highly devitalizing.

These branches on the tree which are obliquely inclined and which are fully exposed to the sun are all capable of bearing fruit-bearing shoots all along their exposed lengths, and, therefore, on no account should they ever be cut back or pruned in any manner.

TREATMENT OF BEARING TREES

Both sweet and *santra* oranges begin to bear small crops from the fourth year after planting, but they bear substantial crops from the seventh year. It is from this age onwards of the trees that they require a special cultural treatment called 'resting' which enables them to blossom profusely and set a heavy crop of fruits. This treatment of 'resting' is not necessary in north India. The blossoming period of oranges differs in different climatic zones of India, and, therefore, the time of giving the annual cultural treatment also differs in different tracts.

Blossoming seasons of oranges. In the climate of northern India with distinct winter and summer seasons, the sweet as well as *santra* oranges put out blossoms only once in a year in the early spring, i.e., in March, and mature fruits nine months later in November and December.

In the more even climates of central and western India, oranges produce new leafy growths and flowers three times a year at intervals of four months, i.e., in June, October and February. The February flowering is called *ambebahar,* the June flowering *mrigbahar* and the October flowering *hastbahar.* Not that the trees normally flower in all these three seasons. The intensity of flowering depends chiefly on the vigour of the trees as influenced by the prevailing weather. If left to nature, the trees may blossom and fruit very irregularly in any one or all the tree seasons, and give irregular small crops at indefinite intervals.

To get over this difficulty and to force a full crop of fruits in any one of the three flowering seasons as required by the trade, a method of treating the orange trees has been practised in the Deccan and Madhya Pradesh which is called 'resting' or 'root exposure'.

Resting treatment. The 'resting' of orange trees consists in ploughing the orchard and withholding water for a month or two before any one of the three flowering seasons, and exposing the roots of the trees by removing the upper three to four inches of the soil within a radius of 1½ to two feet around the trunk.

The operation of exposing the roots is so carefully done as to never cut or bruise the massive thick roots which form the main framework of the root system. After these roots are exposed, the clusters of minute fibrous roots borne on them are removed by means of a pruning shear.

As a result of the exposure of roots, the water supply from the soil to the top is reduced to the minimum, and therefore, the leaves begin to shrivel or turn yellow and fall. The condition of leaf-fall indicates that the tree has rested enough and has gathered plenty of food reserves in its branches. At this stage, the exposed roots are again covered with the original soil. The irrigation basins and water channels are then prepared, and necessary manures are mixed with the soil in each basin. The whole orchard is then immediately watered.

The second watering is given on the third day so as to quickly moisten the lower layers of the soil in which most feeding roots abound. Subsequent waterings are given at weekly intervals or as would be demanded by the prevailing weather conditions. Within 20 days of the first watering, the trees flower profusely and set a heavy crop of fruits.

To cause the complete resting of the tree, it is not always necessary to expose the roots. In sandy, gravelly, light or shallow soils, a mere stoppage of water for a few days, say about two weeks, and ploughing of the orchard may cause the wilting of leaves. It is only in the case of very deep, heavy, clay soils which are highly retentive of water that the root-exposure is necessary in addition to ploughing and stoppage of irrigation. In such soils, the roots have to be kept exposed for a month or two to cause the wilting of leaves.

Ploughing should be so shallow as to disturb only the fibrous roots which abound in the first nine inches of the surface soil. Ploughing deeper than nine inches will damage the thick roots below, and consequently, the tree will be devitalized. Similarly, as already stated elsewhere, the part of the root system beyond the two feet radius from the trunk should never be exposed.

Choice of *bahar*. The grower himself has to decide in which of the three flowering seasons he should force his orange trees to flower so that he may be able to harvest a full crop at a time of the year when he can get the maximum profits. For instance, if he wishes to market his fruits in November or December, he should treat his trees for the *ambebahar* (February or spring flowering).

Besides marketing, there are other problems which need consideration in making the choice of a *bahar*. In the Bombay Deccan, the growers who have little water in the wells in April and May, do not treat their trees for *ambebahar* or *hastbahar* as large quantities of water would be required by the fully laden trees during summer. In such circumstances, they prefer to take the *mrigbahar*, so that the trees would be rested in April-May, and no watering would be required then, and as the flowering of *mrigbahar* would commence with the onset of the rains in June, sufficient water would be available in the wells for irrigating the crop during the monsoon and the following cold weather, when the fruits would mature.

Similarly, in localities where an attack of the fruit-sucking moth on ripening fruits is feared in the middle of the South-west monsoon, i.e., in July-August, the *hastbahar* treatment is avoided.

It must be borne in mind that orange trees treated for *bahars* usually get habituated to flowering in a particular *bahar* and do not satisfactorily respond to frequent and abrupt attempts at changing over to another cropping season. It is always wise, therefore, to fix any one of the three cropping seasons and treat the trees for the same *bahar* year after year.

In the more tropical zones of southern India which receive rains from the South-west as well as the North-east monsoons, the treatment of withholding water and thereby resting the trees at a particular time of the year is not practicable due to irregular rains spread over the greater part of the year. In this climate, the blossoming periods or *bahars* are spread over a period of four to five months as against a month or two in the dry climate of the Bombay Deccan, and often the blossoming of one *bahar* overlaps the maturing crop of the previous *bahar*.

For instance, the blossoming of the main crop of the *Sathgudi* orange in Rayalaseema occurs gradually from December to April, and the harvests last from the following November to March. For the off-season crops, flowering occurs from September to the beginning of December, and the fruits are harvested from the following June to November. The main picking season for *santra* in Mysore is from December to April, and the off-season fruits are harvested from July to September. In the Circars in Andhra, October to January is the main harvesting season for *Sathgudi*.

In the Punjab and Uttar Pradesh, orange trees do not require artificial resting treatment as in the Deccan and Vidarbh. Here, they flower only once in the year, in spring, and mature their fruits from November to the end of March. During and after the harvest, the trees take complete rest, and do not produce new growths due to an extreme cold from November to the end of February. Irrigation is given during the resting period because of the crop on the trees.

Manures and manuring. The kinds and quantities of manures given annually to a full grown orange tree over seven years in age will vary according to the soil conditions prevailing in a particular area. In the alluvial plains of the Punjab and Uttar Pradesh, a mixture of 60 pounds of farmyard manure and four pounds of sulphate of ammonia per tree is considered satisfactory. In the medium black soils of the Bombay Deccan, 80 pounds of farmyard manure, ten pounds of castor cake and two pounds of superphosphate have given good results, and in the red lateritic soils of the wet zones of south India, a mixture of 80 pounds of farmyard manure, ten pounds of bonemeal and ten pounds of wood ash is recommended. For the *santra* orange in Vidarbh, 100 pounds of farmyard manure per tree is usually given.

Square or round water basins, as large as the spread of the tree crowns, are made and the manure is spread evenly all over the basin and then deeply dug in by means of a hand spade.

Irrigation. Immediately after manuring, the trees are watered. This first watering merely wets the upper loose soil to a depth of three to four inches. To wet the lower layers of the soil quickly, the second watering is given on the third day after the first irrigation. Subsequent waterings are given at intervals of seven to 15 days according to the soil and the prevailing weather conditions. Clay soils may require water at much longer intervals than sandy soils. During winter, the water may be given at intervals of ten to 15 days, and, during summer, at weekly intervals or even at still shorter intervals in the case of highly porous sandy or shallow soils.

The watering of the orchard should be continued at regular intervals throughout the fruiting period, till the fruits are harvested. A shortage of water at the time of blossoming may result in the dropping of flowers and newly set fruits and a shrortage during the maturing period may cause the shrinking of the fruit and the drying of its pulp.

Hoeing and weeding. The soil in the water basins is likely to pack hard under continuous irrigation, and, therefore, it should be given a light hand-digging after every three irrigations so as to maintain porosity and tilth. The operation is best done by means of a hand spade called *kudal*. Hand-digging would also help in keeping the orchard free of weeds. Under no circumstances should weeds be allowed to grow rampant in the garden. About three weedings will be necessary during the monsoon to check their growth.

Protection against sunburn. The climate in most parts of northern India is extremely hot during summer. A good deal of the orange crop especially *santra,* gets sunburnt, particularly on the south-west side of the tree. Many a time, trunks or main branches of trees if exposed to direct rays of the sun also get sunburnt, resulting in the cracking of the bark. Sunburn can be prevented effectively by keeping the tree low-headed by proper shaping and training when young so that its trunk is protected against the hot rays of the sun by the shade of its branches. Exposed trunks of badly trained trees should be covered with straw, paper or gunny cloth. Another very effective method is to whitewash the trunks of trees.

Protection from wind storms. In most parts of the plains of northern India, wind storms and dust storms during summer are frequent and severe, and cause shedding of the fruit. To minimize the effect of strong winds, the planting of wind-breaks all around the orchard is indispensable. The wind-break tree may be *shisham,* mulberry, *jaman,* etc. It is desirable to plant the wind-breaks one or two years before the orange trees are planted, so that they will be tall enough by the time the latter come into bearing.

Protection from frost. Grown up orange trees are generally hardy enough to stand casual freezes of short durations, but severe freezes of long durations which occur continuously for three or four days, registering night temperatures below 30°F, may prove destructive. Small trees may be killed to the ground and branches of large trees half-killed. The danger of frost can be minimized to a great extent if plantations are protected on all sides by tall wind-breaks and frequently irrigated during frosty weather so as to keep the orchard air more humid.

Orchard hygiene. The orchard should be kept absolutely free of deep-rooted weeds, the *Loranthus* parasite and various kinds of pests and diseases. Remedial and preventive measures to check them must be taken at the proper time as advised in the chapter on pests and diseases.

HARVESTING AND MARKETING

Both the sweet and *santra* oranges mature their fruit about nine months after blossoming. They are considered fully mature for picking when they change colour from green to orange yellow. The colour is not always the criterion to judge the maturity of oranges, as in the high rainfall tracts they sometimes remain green externally even though the pulp has sweetened and changed colour within. In such circumstances, a few fruits may be plucked from each tree and cut to see if they have developed the characteristic flavour and taste of the variety.

Sweet oranges, after changing colour on the tree, can keep long without spoiling, and, therefore, they can be held over the trees for several weeks if desired; but *santras* must be harvested as soon as they ripen as, otherwise, they would shrink, lose weight and drop down. Again, one and all fruits on a tree may not fully mature at one time and become ready for picking, especially in those tracts of south India where the blossoming season ranges over several months. In such cases, fully mature, large-sized fruits have to be carefully selected and picked from time to time.

The fruit should be clipped with its stalk and not pulled off, as such a pulling tears away the rind, as often happens with the *santra* oranges. The fruits should be carefully handled during picking and packing for the market without in the least bruising the rind. The practice of hauling oranges to local markets piled loose in ox-carts results in much damage. Packing sheds must be provided near the plantations and fruits must be packed immediately within a day or two of picking.

Oranges should be sorted out for quality, graded for size, polished lightly by means of a piece of cloth, and individually wrapped in tissue paper. They should then be packed tightly in suitable baskets or boxes for transport by road or rail to the distant markets. Rice straw or any kind of soft dry grass is excellent for padding around the fruits inside the package.

A step-ladder should be used to pick fruits borne at the top of the *Santra* orange tree

Oranges are usually packed in light bamboo baskets which are badly handled at railway stations by porters, and a large proportion of the fruit is spoilt before reaching the retail market. It is always better to use ventilated dealwood boxes in which they do not suffer any damage. Sweet oranges have a fairly thick and tough rind, and can safely be packed about 100 fruits to a box, but *santras* have soft, brittle, and easily breakable rind, and, therefore, should not be packed more than 50 fruits to a box, so that fruits in the bottom layer are not subjected to any appreciable pressure.

Cold storage. *Santra* oranges are quickly perishable. They lose their freshness, shrink, and become stale within a week after harvest. Sweet oranges remain in fairly wholesome condition for more than a week, but they also lose their marketable appearance within a fortnight after harvest, if stored at ordinary room temperature.

During a part of the harvesting season, there is often a glut of oranges in local markets, and as the fruit is quickly perishable, large quantities are offered for sale within a short period of time and prices drop to uneconomic levels. It would, therefore, be a great advantage to the grower if the surplus fruit could be held back for some time in a good marketable condition to enable marketing to be extended over longer periods of time. It is possible to do so by keeping oranges in cold storage chambers at low temperatures.

It has been observed at the Ganeshkhind Fruit Experiment Station, Poona, that fully mature *Nagpur Santra*, i.e., just developing a tinge of yellow, develop colour and juice flavour when stored at 52°F for about two weeks. After the fruit has assumed a fully ripe colour, it can be stored for a further period of three months at 40°F without deterioration in colour and quality. Similarly, *Mosambi* which is pale yellow in colour when freshly picked, develops a deep and uniform orange colour and also improves in its juice quality after three months storage at 52°F.

The *Blood Red Malta* oranges obtained from the Punjab and stored in the cold storage at Poona at 40°F remained in fresh, wholesome condition for four months. Observations on the cold storage of oranges carried out at Lyallpur (West Pakistan). showed that *Valencia Late* kept in good condition for 4½ months, *Common Malta* for four months and *Blood Red Malta* for three months at temperatures ranging from 36° to 39°F.

Preservation by wrapping in pliofilm paper. A recent observation made at the College of Agriculture, Poona, is that

Mosambi oranges wrapped individually in pliofilm (transparent wrapping paper) and stored at room temperature (80°F) kept in fresh marketable condition for over two months. This observation suggests that we need not store sweet oranges in costly cold storage chambers if we can preserve them for long periods at ordinary room temperature by simply wrapping them in a cheap paper like the pliofilm.

YIELD

The yield of sweet oranges is estimated at about 100 maunds per acre in Madras, the Punjab and Uttar Pradesh, 140 in the Bombay Deccan and 180 in the former Hyderabad State. In Vidarbh, the yield of *santra* oranges is about 110 maunds per acre. In good orchards, the average yield per tree of sweet orange (ten to 20 years in age) may range from 500 to 600 fruits, and that of the *santra* from 1,000 to 1,500 fruits.

DURATION OF THE PLANTATION

Both sweet and *santra* oranges are expected to bear fairly good crops up to the age of 30 to 40 years under favourable conditions. After this age, yields begin to decline, and it may not be profitable to maintain the plantation any more. In many parts of India, however, the average life of an orange plantation may not be above 25 years, and in several places where trees usually suffer from various kinds of deficiency diseases, the life of the plantation is even reduced to 12 to 15 years.

LIMES AND LEMONS

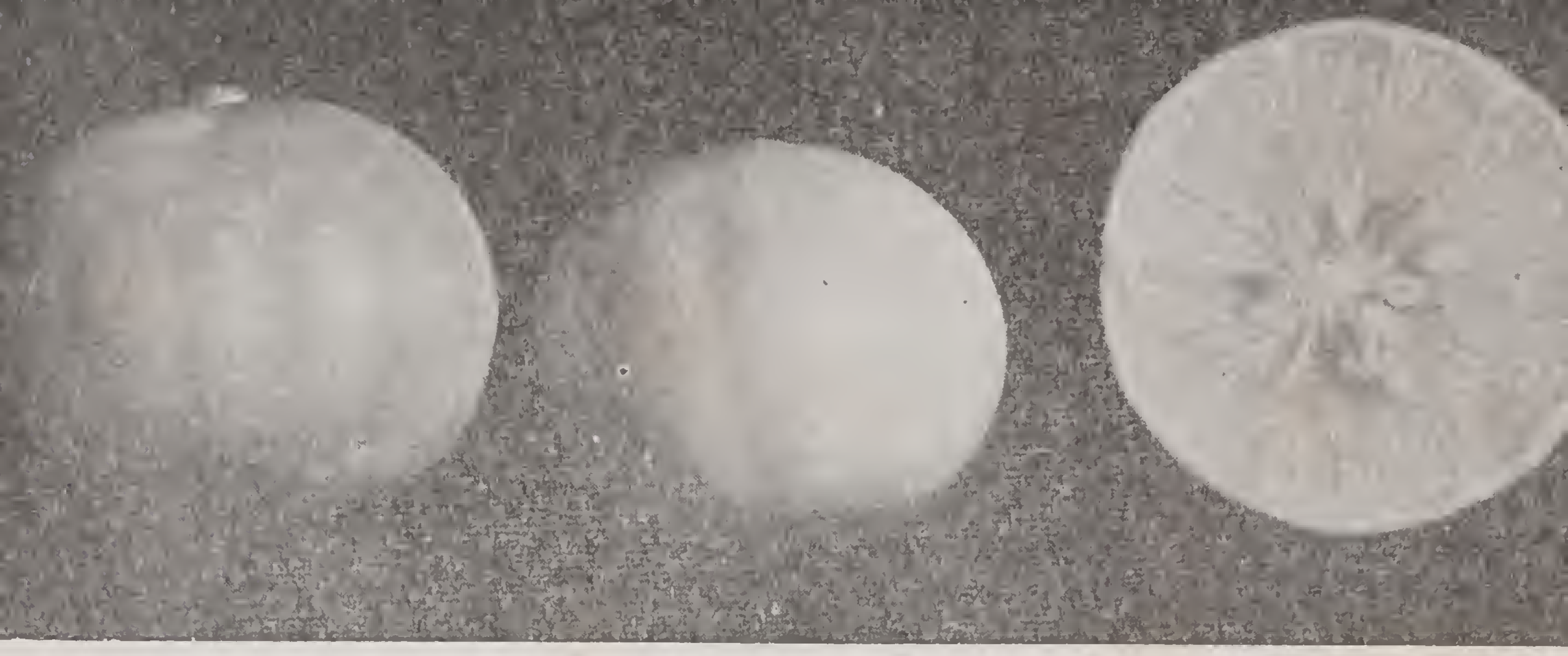
THERE are many indigenous varieties of limes and lemons grown as back-yard plants all over India, but none of these has attained the commercial status achieved by *Kagzi Nimboo.* It is the ony one cultivated on a field scale throughout India, and accepted by the trade as a standard commercial product.

Kagzi Nimboo will grow in all parts of India which are free from frost. Its culture should be undertaken only in regions that are known to be particularly warm, moderately moist and free from severe freezes. The lime is much more tender than the lemon. In sections of northern India where the temperature is likely to fall below freezing point, *Kagzi Nimboo* plantings should not be attempted on a commercial scale.

In western as well as southern India, *Kagzi Nimboo* is successfully grown in the dry climate of the Bombay Deccan, and in parts of the former Hyderabad State, north Mysore, Northern Circars and Rayalaseema in Andhra, where frosts are unknown and the annual rainfall does not exceed an average of 30 inches. A large part of the produce grown in these districts is exported to northern India.

In the more humid regions of western and eastern sea coasts and in parts of West Bengal and Assam with a rainfall higher than 50 inches, *Kagzi Nimboo* contracts a disease known as canker, becomes unproductive and is short-lived.

There is another indigenous lime known as *Rangpur* lime. It is not a true lime, but is in fact a hybrid sour mandarin. In the American literature on citrus, it is popularly known as mandarin lime, as it is similar and related to the loose jacket *santra* group of oranges. The colour of the rind and pulp is orange. The rind is thin and readiy separates from the pulp-ball. The tree is evergreen, spreading in its



This strain of *Kagzi Nimboo* is from the Modi Bagh, Poona

habit of growth and highly productive. It is admirably adapted to the wet and dry regions of northern, western and southern India. It is fairly resistant to canker and also to mild frosts. It can, therefore, replace *Kagzi Nimboo* in the high rainfall tracts as well as in many parts of northern India where the winter is severe.

Another famous variety of hybrid lime is *Mitha Nimboo,* which is grown as a back-yard plant in many parts of India. Probably there are several kinds of hybrid sweet limes growing in different tracts of India. The sweet *Chikna* of Saharanpur and *Mitha Nimboo* of Vidarbh are examples of sweet limes. These limes are mildly sweet with practically no acidity, and have an insipid flavour. They are grown commercially in northern India and for home use in other parts.

Among the indigenous lemons grown in northern India, *Galgal* (hill lemon) is famous in the Punjab and Uttar Pradesh. It is a large, heavy, oval fruit with a few seeds. It is also a heavy cropper, and is very hardy to both heat and cold.

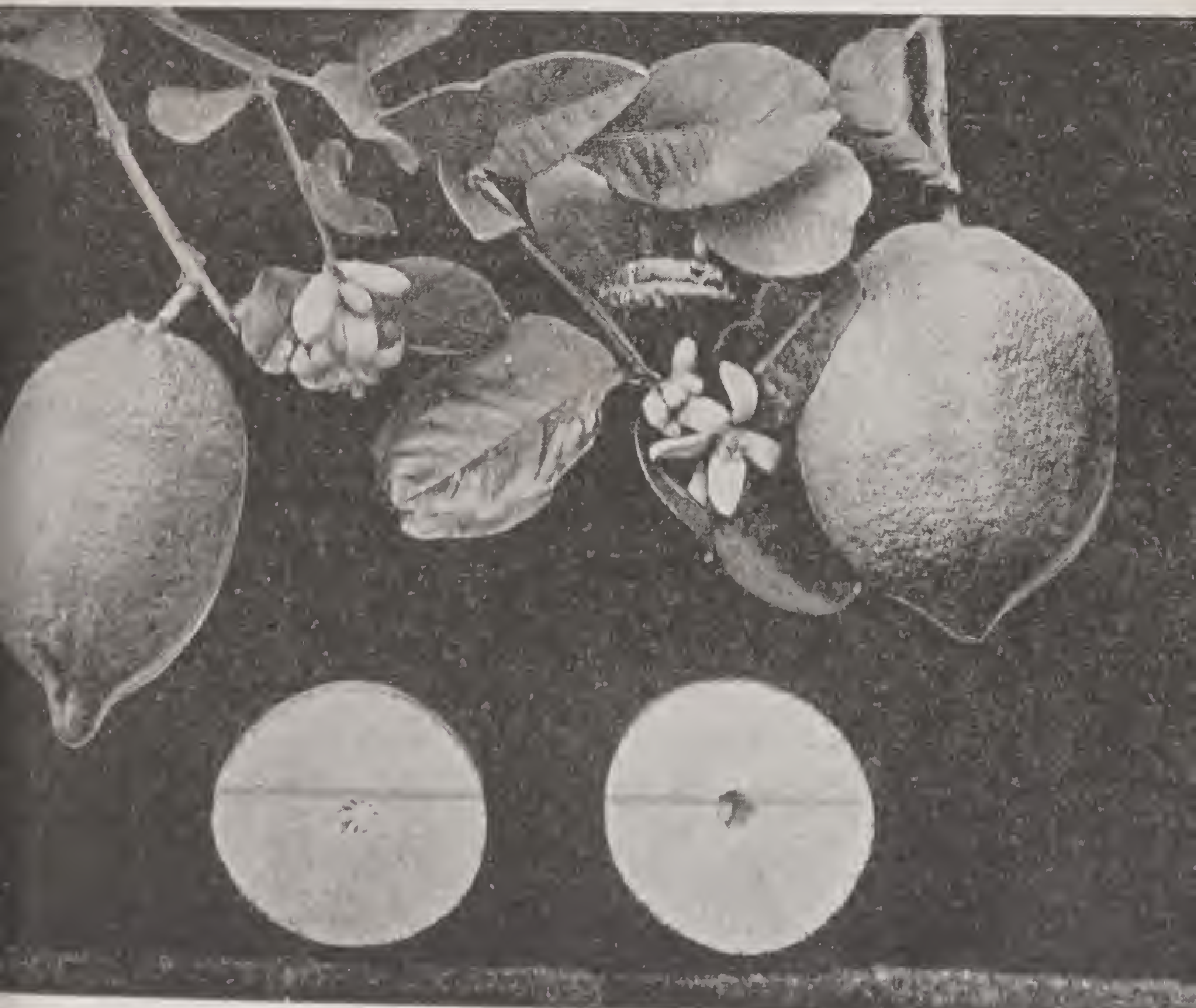
Among the introductions from Europe, *Italian* lemon is the most important. It has admirably adapted itself to varied conditions of dry and moist climates in different parts of India. *Italian* lemon is a large, oval fruit with a prominent nipple. It is perfectly seedless and has a thick rind and juicy pulp for which it is much prized for pickling and for making cold drinks. The home-grown *Italian* lemon compares favourably with *Jaffa* lemon, which is sometimes imported into the

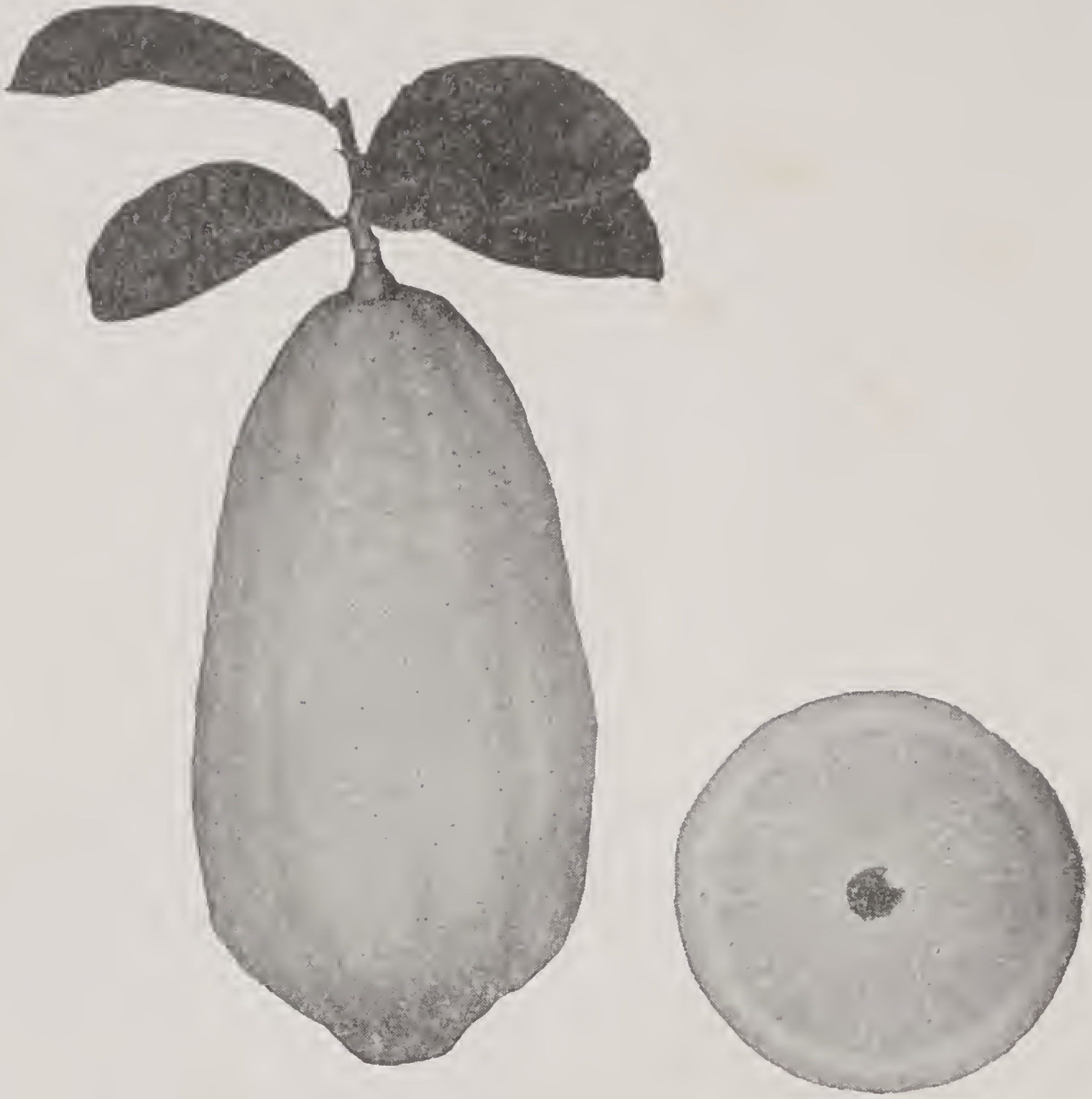
Bombay market from Palestine. *Italian* lemon is found to crop prolifically in the Deccan and the drier zones of southern India; in the high rainfall tracts too it is found to crop fairly well.

An indigenous lemon known as *Pat Nimboo* in the Bombay Deccan is a prolific cropper, though a little inferior in flavour to *Italian* lemon.

Among the most recent introductions of lemons from America and Europe, the most prominent are *Eureka, Lisbon* and *Villa Franca* which are still under trial on various government farms in the country . In trials on the farms of western and southern India, none of these varieties has so far shown any superiority over the *Italian*.

Italian **lemon**





Pat **lemon**

PROPAGATION

Kagzi Nimboo is usually propagated from seed all over India, though 'budding' is being adopted as an improved method in some parts of the country. As a tree grown from seed begins to bear fruit sometimes as early as three years after planting and can stand the rigours of heat and cold better than a budded plant, and because it also bears fairly heavy crops of a more or less uniform quality, growers in many parts of India prefer to propagate *Kagzi Nimboo* from seed and not by budding.

Freshly extracted seeds are sown on raised seed-beds. When the seedlings are about three to four inches in height, they are transplanted nine inches apart in flat beds. With due care in cultivation, manuring and irrigation, the seedlings become ready for transplanting in their permanent places after a year in the following monsoon.

Italian lemon, which is seedless, is propagated by budding on *Jamburi* or any other root-stock found suitable in the tract concerned, as is done in the case of oranges. The root-stocks found suitable for budding oranges in different parts of the country are also generally suitable for budding limes and lemons.

PLANTING, TRAINING AND CARE OF YOUNG TREES

Trees of the *Kagzi Nimboo* are of small size and can, therefore, be planted closer together than trees of the lemon varieties. The best planting distance for the whole country in general is between 15 and 18 feet apart. In the Indo-Gangetic plains (Uttar Pradesh), where the growth is luxuriant, an 18 to 20-foot spacing is desirable. In the shallow soils of the Bombay Deccan and the Hyderabad Deccan where the growth is poor, the spacing given to *Kagzi Nimboo* is only 12 to 15 feet, but in the deeper soils of East Khandesh, it is generally 18 to 20 feet for seedling trees.

Similarly, for the moist climate of south India where the plant grows more luxuriantly than in the Bombay Deccan, a 20-foot spacing is recommended. The *Italian* and other lemons should be spaced 20 to 25 feet apart as would be warranted by the growth of trees in the conditions of soil and climate obtaining in different parts of the country.

The operations of planting, irrigation, manuring and care of young trees including the training of trees and removal of water-shoots are just the same for both limes and lemons as already prescribed for oranges.

Italian lemon and *Rangpur* lime being straggling and spreading in their habit of growth, their branches are better tied or allowed to droop horizontally on a low, rectangular, bower-like, wooden framework. They are more productiv when thus trained, and their fruits hanging vertically an shaded by the foliage do not get scorched as in trees whic are not trained on bowers.

TREATMENT OF BEARING TREES AND CROPPING

Both lime and lemon trees begin to fruit from about th fourth year after planting. They are by nature continuou fruiters. They put forth new growths and blossoms at a times throughout the year, and their fruits mature six month after flowering. They do not take rest, and attempts to regulate their blossoming seasons or *bahars*, as in the case o oranges, by giving artificial rest by exposing roots have no met with much success.

Light crops of *Kagzi Nimboo* are continuously harveste every month of the year as a result of successive flowerings, s that a tree will have new flowers, small immature fruits an fully ripened fruits at one and the same time. However, according to the varying climates, the periods of maximum an minimum harvest differ in different parts of the country. Fo instance, in Gujarat and the Bombay Deccan, about 60 pe cent of the year's crop is harvested from July to Septembe about 30 per cent from October to January, and ten per cen from February to May. In south India, the season of maximum harvests is limited to March-April in the Circars, Jul to September in Rayalaseema, June to August in North Arco April to June in Guntur and Nellore, and January to Marc in Tinnevelly. In northern India, the season of maximu harvest is from August to September.

The lemon varieties show almost the same behaviour flowering and fruiting as that of *Kagzi Nimboo.*

The following schedule of annual operations may be followed for *Kagzi Nimboo* in the dry districts of India in whic the season of maximum harvest occurs during the South-we monsoon.

SCHEDULE OF OPERATIONS

(1) After harvesting the major crop in the middle or the end of the monsoon, stop giving water and rest the plantation in October. When the weather gets dry at the end of October or in the beginnng of November, plough or harrow the orchard and dig the ground underneath the trees with a hand spade. Remove water-shoots and deadwood, if any.

(2) Manure the trees in December or January after harvesting the cold weather crop and irrigate well before the spring flowering occurs in February. A well-grown tree ranging from seven to 20 years may be given 80 pounds of farmyard manure, ten pounds of castor cake or groundnut cake and two pounds of superphosphate.

(3) When the fruits of the spring flowering attain the size of a little bigger than a pea, spray the trees with lime-sulphur wash as a preventive against mites and thrips.

(4) Irrigate the trees at regular intervals during the cold and hot weathers as suggested in the chapter on oranges, and dig the soil of the basins after every three or four irrigations to prevent it from packing.

(5) Before the South-west monsoon begins, give a spray of Bordeaux mixture (3-3-50) as a preventive against canker and withertip and repeat the spraying in case these diseases persist in the plantation.

HARVESTING, YIELD PACKING AND STORAGE

Fruits of limes and lemons are considered ready for picking when the colour of the rind begins to turn yellow. As fruits of different stages of maturity occur on the tree, the greenish yellow fruits of big size have to be marked out and picked. Lemons are carefully clipped from their stalks by hand-clippers but *Kagzi Nimboos* can be harvested by means of a pole-harvester to the end of which an iron hook is fixed. The mature *nimboos* are thus felled on the ground and collected.

A *Kagzi Nimboo* tree above eight years in age in the most favourable soil and climatic conditions would yield an annual crop of about 1,600 fruits weighing abut two maunds. The *Rangpur* lime yields about 1,800 fruits and the *Italian* and *Galgal* lemons from 600 to 800 fruits annually.

The *kagzi* lime fruits are hardy, and can stand rough transport. They can be packed in bulk in bamboo baskets and despatched by rail to any distant market.

Kagzi limes can be stored in fairly good condition for a month at ordinary room temperature if placed in partially closed tins. Limes which are green or pale yellow at the time of storage become bright yellow as a result of storage in a container at ordinary temperature. They can also be stored in fresh condition for two months at 52°F in cold storage.

PESTS AND DISEASES OF CITRUS

LEMON CATERPILLAR is the caterpillar of the lemon butterfly (*Papilio demoleus*). The butterfly lays eggs singly on the leaves. The caterpillar on hatching feeds voraciously on the leaves. The young caterpillar is brown with white markings, and nearly resembles the droppings of birds, but, when full grown, the colour changes to a vivid green with brown markings. When full-fed, the caterpillar pupates on the plant with a girdle of thread around its body. After a few days, the butterfly comes out of the pupa. Mostly nursery plants of oranges and lemons in seedling stage are attacked, particularly during the monsoon.

If the attack is on a small scale, the caterpillars can be picked by hand and killed by throwing them into kerosene. If found on a large scale on grown-up plants, the plants should be sprayed with 50 per cent DDT ('Guesarol' 550). A pound of 'Guesarol' should be mixed with 20 to 30 gallons of water. The first application should be made when the young green caterpillars appear on the leaves. The second spraying may be given about three weeks later if the attack persists.

The citrus shoot and bark borer. This is a caterpillar of a moth called *Arbela tetraonis.* The moth lays eggs under the loose bark, and the hatching caterpillar bores into the stem and bark; it moves about in a gallery of powdered bark, feeds on the bark and also bores into the stem in some shoots. The caterpillar when full-fed measures about an inch and a half in length, and has a dirty pale brown colour with a darkish head region.

The caterpillars can be forced out of the holes by hooked wires, or a small quantity of a mixture of petrol and naphthalene may be injected into the hole by means of a syringe. Also, a concentrated solution of 50 per cent water dispersible

DDT (a pound in 100 gallons of water) may be smeared on the trunk. In this way, the larvae which come out for feeding at night are poisoned and killed.

The citrus stem borer. Ths is a stout grub of a kind of beetle, called *Chloridolum alcamene.* When symptoms like surface holes or galleries throwing out a fibrous powdery matter are seen, the grubs should be extracted by hooked wires or destroyed *in situ* by injecting diluted kerosene or patrol, and the holes covered with wet clay. Sanitary measures in the orchard by way of cutting off all dry branches, scraping the loose bark from tree stems and not allowing dead trees to remain in the orchard will go a long way in warding off the attack.

The citrus fruit-sucking moth (*Ophideres* sp.). This is a moth having grey and orange-coloured wings. The moth punctures the skin of the ripening orange and sucks its juice and lays eggs in the pulp. Fruits so damaged gradually begin to rot and drop down. These moths visit the fruits only at night and are not seen during the day. The pest appears only on fruits ripening during the heavy rains in western and southern India. In western India, it can be avoided by not treating the trees for the *hastbahar*. It is a serious pest in the Circars, Rayalaseema and the central district of Madras, where orange trees are not treated for selected *bahars,* but are allowed to flower and fruit naturally over a large part of the year including the monsoon.

The only effective remedy is to cover individual fruits, when they are half ripe, green and hard, with kraft-paper bags as the moth is unable to pierce through the paper. If a large plantation is to be treated, the fruits shoud be sprayed with 50 per cent wettable DDT in concentrations of one pound 'Guesarol' in 30 gallons of water.

Citrus leaf miner (*Phyllocnistis citrella*). This is an extremely tiny caterpillar of a small greyish moth. It mines into the surface of young citrus leaves and makes them curl. Attacked leaves show glistening, irregular galleries or mines on the leaf surface, and often the tiny caterpillar is found inside them. The infected leaves get distorted, dry up and fall.

If the attack is on a small scale, the attacked leaves may be removed and burnt; if the attack is on a large scale, the trees may be treated with a spray containing a pound of nicotine sulphate 40 per cent, four pounds of soap and four pounds of 50 per cent wettable DDT in 80 gallons of water. The spraying should be done thrice at intervals of 20 days, after the new growths have been put forth.

Aphids (*Toxoptera aurantu*) **or plant lice**. These are exceedingly tiny, green or black, sucking insects, found adhering in clusters to the underside of young citrus leaves. The attack is generally most virulent in winter in western India when the weather remains cloudy for a long time. The attacked leaves get severely curled and deformed, and the growth of young shoots is checked. Sometimes, even the blossoms and newly-set fruits are attacked. Aphids secrete a sweet honey-like substance on which a black fungus called 'sooty mould' grows, and seriously impairs the normal functioning of the leaves.

Aphids are generally destroyed in nature by another predatory insect called 'lady bird beetle', which feeds upon them, but in the absence of a sufficient number of lady bird beetles, attack may reach dangerous proportions, and, therefore, measures to control aphids should be taken before much curling of the leaves has occurred. A spray containing a pound of nicotine sulphate (40 per cent) and four pounds of soap in 80 gallons of water is found very effective. Another chemical called 'Pyracolloid' diluted one in 800 parts of water is also equally effective in destroying the pest.

Mealy bugs. (*Pseudococcus citri*). These are small, oval, sucking insects with a cottny white waxy covering on their bodies. They are found sticking to the underside of orange leaves and the base of the fruit near the fruit-stalk. In the case of a serious attack, considerable dropping of newly-set fruts occurs. Mealy bugs generally occur in neglected plantations.

In nature, mealy bugs are preyed upon by the lady bird beetle. In case of a serious attack, nicotine sulphate diluted one in 600 parts of water should be sprayed. The plantation should always be kept free of red ants, as they are greatly responsible for distributing mealy bugs from one tree to another. Red ants may be killed by dusting a mixture of 'Gammexane' D .025 (5 per cent BHC) in combination with sulphur in the proportion of 2 to 1.

Citrus white fly (*Dialeurodes citri*). This is a serious pest of oranges in the Punjab. It is a very small, scale-like white insect, about 1/5 inch long. It lays its eggs on the underside of orange leaves. When numerous, the eggs give the leaves the appearance of being covered with a pale yellow powder. The young ones hatching out of these eggs are like aphids. They suck the sap from the leaves and also secrete a sweet honey-like substance on which the sooty mould fungus grows and interfers with the normal functioning of leaves. In nature, the lady bird beetle feeds upon the young ones of the white fly. Rosin compound shoud be sprayed on the underside of leaves for an effective control.

Citrus psylla (*Diaphorina citri*). This is a kind of plant lice attacking the young leaves of oranges in the same manner as the young ones of the citrus white fly. The young ones of citrus psylla are orange-coloured, and suck the sap of leaves and excrete a honey dew on which develops the sooty mould fungus. In the Punjab, the attack of citrus psylla is sometimes so serious as to cause a complete loss of crop for several seasons, and afterwards, the death of most branches and sometimes the death of entire trees in orchards. For controlling the pest, tobacco decoction should be sprayed in spring, and rosin compound in winter.

Fruit fly (*Chaetodacus* sp.). The fruit fly is occasionally a serious pest in western and southern India, especially during the monsoon. The fly is almost of the size of a common house fly. It can be easily distinguished from the ordinary fly by its triangular-shaped abdomen and spotted wings. The fly lays eggs by means of its piercing ovipositor under the rind of the fruit when it is about to ripen. Within a few days, the eggs hatch out and young white maggots or worms start feeding deep into the soft pulp. The infested fruit can be recognised even at an early stage of attack by the presence of a rotten, round patch at the place where it was pierced by the fly. Affected fruits drop on the ground and the maggots pupate in the soil and emerge as flies after a week or ten days.

The fruit fly control consists in preventive measures only. The attacked fruits should be collected and burnt so that the maggots emerging out of the fruits may have no chance to pupate and give rise to further generations of the insect. As the fly chiefly attacks the fruits ripening during rains, it is possible to avoid it altogether by treating the orange trees for *bahars* other than the *hastbahar* in western India as already suggested for controling the fruit-sucking moth. The only effective remedy is to cover individual fruits when they are half-ripe, but still hard and green, with kraft-paper bags as the fly is unable to pierce through the paper.

If the attack is on an extensive scale in a plantation, it is possible to kill the adult flies to some extent by spraying the trees with a bait mixture containing one ounce tartar ametic and 24 ounces of *gur* in 20 pounds of water.

Thrips. The thrips are too minute to be seen with the naked eye. The pest attacks young twigs, leaves and fruits. The thrips feed upon the surface of the fruit by puncturing and by rasping the tissues, which results in a characteristic scarring of the fruit. The scarring usually consists of a fairly uniform and distinct ring encircling the stem of the young orange fruit. As the fruit grows, the scarring may not appear in the form of a ring, but as irregular, pitted streaks. The attacked leaves become leathery in texture, deformed and curled. It is a serious pest on *Mosambi* and *santra* in the Bombay Deccan.

Lime-sulphur wash may be sprayed as a preventive on the trees when young fruits are of the size of a betelnut.

Mites. These insects, like the thrips, are too minute to be seen with the naked eye. They are worm-like in shape and yellowish in colour. Two kinds of mites are known to attack citrus fruits. The one which turns the rind of orange into a sort of copper-red colour is called the rust mite. Another kind usually attacking lemon fruits is called the silver mite, as it makes the rind of the fruit silvery in appearance. The rust mite is an important pest on *Mosambi* orange in the Bombay Deccan. When a severe attack occurs, the young orange fruit assumes a dark-red brown colour and the undersides of leaves are tainted red. The mites suck the sap from the rind of fruits as well as of green twigs and leaves, which get badly deformed.

Lime-sulphur wash should be sprayed on the trees when the fruits are of the size of a betelnut, as recommended for thrips. As both thrips and mites often occur together in similar climatic conditions, the common spray of lime-sulphur wash will check both these pests.

DISEASES

Citrus canker. This is a bacterial disease of citrus trees which is highly infectious and spreads from tree to tree by contact. It chiefly occurs on *Kagzi Nimboo* in all parts of India. The incidence of canker is comparatively more in the high rainfall tracts than in the dry zones of India. The disease is favoured by a mild temperature and wet weather. It is disseminated in the orchard by wind, driving rains, and by insects, especially the leaf miners. The organism of the diseases (*Phytomonas citri*) remains active over long periods in the crevices of old barks. *Santra* oranges and lemons are resistant to canker, while sweet orange is only partially resistant.

Canker appears in the form of tiny, circular, brown crator-like eruption on leaves, stems and fruits. On the leaves, the canker spots are individually surrounded by yellow-coloured halos, but on the stems and fruits, the spots occur in irregular masses, and, therefore, the halos are not distinctly seen. The canker spots when felt by hand appear rough on both sides of the leaf. In severe attacks, the leaves may fall, twigs may collapse, and fruits may altogether be disfigured and turned unmarketable.

A measure partly effective in preventing canker on *Kagzi Nimboo* is spraying during the first three months after the fruit is formed with Bordeaux mixture. In winter, all diseased leaves and twigs may be pruned and destroyed by burning and the trees sprayed with Bordeaux mixture (4-4-50). Thereafter, the new growths during spring and summer should be sprayed with Bordeaux mixture (3-3-50) once every two months till the fruits are harvested.

Mottle Leaf or Frenching. This is a leaf disease of oranges and lemons caused by the deficiency of a micronutrient, zinc, in the plant body. The soil may be wanting in zinc or the zinc present in the soil may not be in an available form to the tree.

In a tree suffering from zinc deficiency, the normal green colour of the leaves changes to yellowish green between the lateral veins, in contrast to the dark green colour along the midrib and adjacent to the lateral veins. The leaves of terminal twigs become narrow, their growth becomes bunchy, and they tend to stand erect. In extreme cases, the twigs and small branches die prematurely, so that a tree thus affected has a noticeable amount of dead wood in it.

Often, a portion of the tree may be more severely affected, leaving the rest of the tree more or less healthy, but sooner or later, the whole of the tree gets affected and it dies a lingering death after a lapse of three to four years.

Zinc is commonly lacking in an available form in the soils of most of the orange-growing areas of India, and mottling is more intense in soils with a high lime-content and lacking in organic matter. Generally, young orchard trees do not suffer. In the shallow soils of the Bombay Deccan, *Mosambi* orange trees begin to suffer when they are about seven years in age. The new growths produced by the trees during the extreme hot or extreme cold weather show much more mottling than the growths produced during the wet weather of the monsoon.

Applications of zinc to the soil have been found to be ineffective, nay, often harmful to the tree. The method most successfully used to correct zinc deficiency is to spray the new flushes of leaves with zinc sulphate, neutralised with hydrated lime in the concentration of ten pounds of zinc sulphate and five pounds of hydrated lime in 100 gallons of water. Leaves readily absorb the zinc of the spray, and mottling, if any, soon disappears.

The spraying is more advantageously done as a preventive once a year when the season's new shoots have grown for about two months, and have fully expanded their leaves. In orchards normally subject to Mottle Leaf, it is not advisable to wait until symptoms reappear before repeating the spraying. Under such circumstances, the trees should be sprayed annually as a routine practice.

It should also be borne in mind that trees not supplied with sufficient quantities of nitrogenous organic manures show more mottling than trees abundantly supplied with organic manures. Care has, therefore, to be taken so that the trees get sufficient quantities of farmyard manure annually.

Sometimes, another kind of leaf mottling occurs on orange and lemon trees. Young leaves show a network of dark green veins on lighter green background, but unlike zinc mottling, their size is not reduced. This mottling is caused by the deficiency of manganese in the plant body. The treatment of such trees consists in spraying with manganese sulphate neutralised with hydrated lime in the concentration of three pounds of manganese sulphate and 1½ pounds of hydrated lime in 100 gallons of water.

Often, the mottling of leaves due to zinc and manganese deficiencies is noticed on the one and the same tree. In such cases, it would be necessary to give a combined spray of zinc and manganese sulphates in the proportions of ten pounds of zinc sulphate, ten pounds of manganese sulphate and ten pounds hydrated lime dissolved in 200 gallons of water.

Withertip. This is a fungoid disese of the young terminal twigs of orange and lime trees. On mature leaves, brown, pimple-like, watery and cloudy spots occur. The spots are at the margins or tips of the leaves. The twigs wither and shrivel one to several inches at the tips, and assume a silver grey appearance. Ultimately, the leaves dry up and the flowers and young fruits drop down.

The withertip fungus is unable to attack healthy, vigorous trees. It enters the tree only as a secondary invader after the tree has been devitalized by some other agency, such as frost, insects, malnutrition, heavy cropping and extremely hot weather. Withertip is reported to be causing widespread damage in the drier zones of northern India, especially the Punjab.

Early in February, the diseased twigs should be cut back to their healthy portions. All diseased branches should be collected and burnt. The trees then should be invigorated by the application of a good dose of farmyard manure and sprayed with a combined spray of ferrous sulphate and Bordeaux mixture in the concentrations of copper sulphate four pounds, ferrous sulphate four pounds, quicklime eight pounds and water 50 gallons.

Pink disease (*Corticium salmonicolour*). This is a fungoid disease of both sweet and *santra* oranges. Its occurrence on *santra* has been reported from the high rainfall tracts of Assam and Balaghat district of the former Madhya Pradesh State, and on *Sathgudi* oranges in North Arcot and Chitoor districts of Madras State.

Its first appearance on the branches of the orange is usually a slight gumming. The bark becomes dry and hard, adhering closely to the wood, and cracks longitudinally, exu ing gum. Later, a pinkish-coloured fungus grows over tl diseased surface, and in the advanced stage, the bark becom a dry mass of shredded fibres, with the result that the pa above the diseased bark dies out.

The dead branches should be pruned and burnt. Tl diseased parts on the branches should be searched out, scra ed, and the wounds painted with Bordeaux paste during tl dry season and the trees sprayed with Bordeaux mixtu (3-3-50) well before the rainy season begins.

Powdery Mildew (*Oidium tingitaninum*). Powdery Milde is reported to occur on *santra* orange in the moist, sub-mo tane tracts of the Kotagiri and Shevroy hills of south Indi A white powder-like growth of the fungus develops on tl young twigs, leaves and young fruits. It is easily identifie by white patches which occur on the upper surface of tl leaves. The young leaves may shrivel, becoming dry ar adhering to the twig. The disease can be controlled by dus ing the trees with a fine grade dusting sulphur.

Leaf Fall and Fruit Rot of oranges (*Phytophthora* sp.). Th disease is reported to occur on *santra* oranges in the moi zones of Wynad and Coorg in south India. The leaves r and shed, leaving the branches bare. Fruits become soft ar rotten, covered with a white downy growth of the fungus ar fall off. Bordeaux mixture (5-5-40) should be sprayed on tl trees, once towards the end of May or beginning of June b fore the monsoon, and again in July-August, when there is break in the monsoon.

Brown Rot, Gummosis or Foot Rot. This is a fungoid diseas of the basal part of the trunk in which the bark exudes gur cracks extensively, dries up and ultimately falls off, expo ing the wood. Infection takes place through the bark frequen ly at the point of the bud union. The infection spreads rapic ly and vertically, but slowly horizontally. It is necessary fc the bark to be wet, either by rain or irrigation to get infecte The fungus lives in the soil and generally attacks the scio trunk at or immediately above the bud union, particularly in the cases of trees that have been planted so low as to have their bud unions touching the ground. For the same reason, deep planting and the heaping of soil around the trunk are to be avoided.

Susceptibility to the diseases by different species of citrus trees varies greatly. The *Jamburi* root-stock on which oranges and limes are budded in the Bombay Deccan is highly resistant, and is never found to suffer from the disease, while *Mosambi* is highly susceptible, the *Nagpur Santra* mildly and the lime is practically immune.

The planting of low-budded trees should be avoided. Nursery plants which have been budded at a height of six inches on the root-stock should always be selected.

Where infection has taken place, successful remedy is possible if the tree is treated in time. The treatment consists in cutting out all the diseased bark clean with a sharp knife, and also removing a quarter to half an inch of healthy bark beyond the diseased portion on all sides. The exposed wood should then be painted with 25 per cent creosote oil or, alternatively, with crude carbolic acid diluted with an equal amount of water. In course of time, the painted wound will heal, and there will not be any further attack of the fungus if care is taken to keep the tree trunks free from contact with wet soil and irrigation water.

Make the irrigation basin in such a way as to provide a dry zone of soil about 1½ feet radius around the trunk by pulling back from the tree-base a circular ridge of soil.

Limb Gummosis. A type of branch or limb gummosis has been observed on *santra* oranges planted in the white, alluvial, clay soil at Mirpurkhas (West Pakistan). The crotches of the main branches show water-soaked regions which exude gum. The bark ultimately splits and falls off. Mention of this gummosis in Pakistan is specially made here in view of a possible occurrence of the disease on *santra* trees in similar climatic conditions on the verge of the Thar desert on the Indian side in Rajasthan.

Another type of gummosis on *santra* is reported from the wet zones of Assam. The bark of the trunk or main branches cracks in vertical streaks and a gum oozes out. Later, the exuded gum hardens and collects in large quantities at the cracked places in the bark. The gum excludes in abundance during the rains, and frequently ceases entirely in the winter. The disease is caused by the fungus *Phytophthora parasitica.* The fungus survives in the soil, and is carried by the wind and insects.

The invaded tissue should be scraped, the diseased bark removed and the exposed surface of the wood painted with Bordeaux paste.

Die-back diseases. The term die-back is often erroneously and indiscriminately used in India as a group name for all kinds of citrus diseases which are not properly identified and understood by the grower. In Florida (U.S.A.), however, the name die-back is specifically applied to a disease known as Exanthema.

The usual symptoms of this disease are: (1) gum pockets are formed at intervals on the stem of the terminal succulent branches which appear stained, (2) the bark of the twigs cracks and forces out a gum-like substance and (3) brownish, gum-soaked areas appear on the fruit, often accompanied by the splitting of fruit.

Exanthema is now known to result from copper deficiency in the plant body. It is remedied by spraying with Bordeaux mixture (4-4-50), preferably just prior to or during the flush of growth in which Exanthema may be expected.

Actual cases of Exanthema are not reported from any part of India, but the term die-back seems to be loosely and commonly applied to trees dying from various diseases such as Withertip, Mottle Leaf, or to trees dying from malnutrition in abnormal soil and water conditions. In the Bombay

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